Replacement Heating Elements for your furnace may be obtained from

CM INC.

103 Dewey Street, Bloomfield, N. J. 07003
(201) 338-6500

MP MASTER
MA32895

CM Inc.

103 Dewey Street □ Bloomfield, NJ 07003
Phone: (201) 338-6500

CM FURNACES, INC.

103 DEWEY STREET

BLOOMFIELD, NJ 07003

INSTRUCTION MANUAL

870228

FOR

TYPE 1600 VTF (C)-Split FURNACE

CM Inc. High Temperature Industrial and Laboratory Furnaces
103 DEWEY STREET BLOOMFIELD, NEW JERSEY 07003 201/ 338-6500

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6/02/86

CM FURNACES INC.
103 Dewey Street, Bloomfield, New Jersey 07003
Area Code (201) 338-6500

OPERATIONAL SAFETY

Safe operation of any piece of equipment is mandatory. As the manufacturer of your electric furnace we have tried to adhere to all the known safety standards and advise you as the user to install this furnace in accordance with the national electric and fire protection codes and to familiarize yourself with those regulations applicable to your operations.

The potential for electric shock is always present in any piece of electrically operated equipment. The following suggestions are for your protection.

1. Always be certain that the equipment you are using is adequately grounded.

2. If an electrically conductive material is being introduced into a furnace be sure that the operator does not become a conductor to ground.

   A. Wear gloves to protect against shock.
   B. If using a metal rod to push trays make certain that the handle is insulated and the rod is adequately grounded. (Suggest a #16 or 18 stranded flexible wire.)
   C. Install rubber mats in front and behind the furnace so that operators can be isolated from ground.

3. Furnaces are equipped with safety interlock switches to deactivate unsafe electrical potential when guards are removed or service doors are opened. Never bypass or defeat that protection.

4. In the case of wire wound ceramic heating element furnaces, be aware of the fact that you can over long periods of time, wear through the ceramic and make contact with the element wires. Be sure to inspect your furnace periodically to ascertain whether or not this wear condition is becoming a problem with your furnace.

5. If you are ever in doubt concerning the electrical operation of your furnace contact CM Furnaces, Inc. in Bloomfield, NJ, at the above number and seek our advice. Do not take chances.

6/02/86

CM FURNACES INC.
103 DEWEY STREET BLOOMFIELD, NEW JERSEY 07003 201/338-6500

CERAMIC FIBER INSULATION SAFETY

Dear Customer:

In accordance with CM Furnaces Inc. corporate policy and our commitment to keep customers informed regarding the potential health effects of components used in the manufacturer of our furnace systems we would like to make you aware of the following information.

It is important to keep in mind that complete furnace systems as received from CM Inc. are completely safe in all respects for the purpose for which they are intended. The comments below are relevant only with regard to future repair and maintenance.

CM Furnaces Inc. manufactures a broad range of high temperature furnace systems incorporating ceramic materials. To the best of our knowledge zirconia and alumina based fiber and brick products pose no known health hazards. Airborne particulates produced in the handling of these materials should be considered a nuisance dust and handled accordingly.

With regards to alumino silicate (Al-Si) ceramic fibers, preliminary test results at the Los Alomos National Laboratory under the sponsorship of the Thermal Insulation Manufacturers Association (TIMA), indicate that these materials may cause cancer in laboratory animals. The results of the Los Alomos tests, although preliminary and incomplete, have been reported to the EPA under the toxic substance control act. The current tests are part of a comprehensive research program which will be followed by others to provide more complete understanding of possible health effects of ceramic fibers. CM Furnaces will continue to keep all customers advised of relevant test results.

While at the present time there are no known chronic health effects in humans from long term exposure to ceramic fiber, the interim results from the animal study are of concern to us. These preliminary results serve to reinforce our conviction that when performing routine maintenance on CM furnaces, ceramic fiber material should be handled in accordance with the recommended safety procedures outlined in the attachment.

You are urged to make this information available to all employees who may be repairing CM furnace systems and if you need any additional information please do not hesitate to contact our plant in Bloomfield, New Jersey (201) 338-6500.

ATTACHMENT

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6/02/86

CM FURNACES INC.
103 DEWEY STREET BLOOMFIELD, NEW JERSEY 07003 201/338-6500

Attachment

Recommended Handling Procedures For Ceramic Fiber Products

1. Minimize airborne fiber at all times.

2. Wear appropriate NIOSH- or MSHA-approved high efficiency air purifying respirator mask.

3. Wear long-sleeved, loose-fitting clothing. Use protective coveralls. Do not wear contact lenses. Avoid taking soiled work clothes home. Wash work clothes separately from other clothing. Rinse washing machine thoroughly after use.

4. Wear eye protection (goggles) and protective gloves.

5. Wash exposed skin areas gently with soap and warm water after handling ceramic fiber product.

6. Particular care should be taken when working with "used" material which has been in service at elevated temperatures (greater than 1600°F). Such products may undergo partial conversion to cristobalite -- a form of crystalline silica that can cause respiratory disease.

6/02/86

CM Inc. High Temperature Industrial and Laboratory Furnaces
103 DEWEY STREET BLOOMFIELD, NEW JERSEY 07003 201/ 338-6500

RAPID TEMP
SAFETY NOTES

IMPORTANT: READ THOROUGHLY BEFORE PUTTING FURNACE INTO OPERATION.

1. When in operation CM Rapid Temp furnaces may be hot on all outer surfaces. It is important for safety that all personnel are instructed regarding proper operating procedures. Where practical, area signs should be employed to indicate furnace "in use".

2. CM Inc Rapid Temp furnaces are not designed for use with combustible gases.

3. CM Inc Rapid Temp furnaces are electrically heated. Insure that all local and national electrical codes are adhered to during installation. Always replace the protective shield over the power terminals of the furnace before placing it into operation.

GENERAL OPERATING GUIDELINES

AND MAINTENANCE INSTRUCTIONS FOR

CM Fiber Insulated Furnace Systems

OPERATION

All CM fiber insulated furnace systems are designed to be essentially maintenance free. However, the primary insulation and the heating elements are fragile and should not be subject to mechanical abuse. The following suggestions are given to obtain maximum service and life of all components.

INSULATION

1). New furnace linings are organic free but may contain trace amounts of absorbed volatiles which will be driven out of the insulation upon initial heating.

2). All CM fibrous furnace chambers are designed for rapid cycling and initial bake out is not required. It should be noted, however, that slower heating and cooling cycling will prolong the overall usable life. It is recommended that the user avoid opening the furnace door while the chamber is hot which specifically results in decreased door insulation life.

3). The stability of fibrous ceramic thermal insulation depends on a delicate chemical balance. It is important that materials which may contaminate and/or react with the furnace lining be removed prior to heating the insulated chamber.

In order to minimize maintenance requirements all foreign material which may react with the fibrous ceramic insulation should be removed prior to firing. Typical foreign material may consist of:

a). Previously processed material remnants.
b). Vitreous silica which has spalled from the heating elements.
c). Any other foreign materials not originally supplied with the furnace lining.
d). Fluxing agents containing halogens, lead, etc.

4). All wall and roof panels should be inspected at regular intervals. Fibrous ceramic insulation will crack and craze with normal usage. These hairline cracks do not affect overall performance. Large cracks and splits which open after severe cycling may require service. It is recommended that severe cracking be discussed with appropriate CM factory personnel.

HEATING ELEMENTS

1). Do not apply voltages to the elements which exceed that noted on the assembly diagram included in the Owners Manual.

2)* Some elements exhibit a tendency to bow or curl along the heated length. If this curl is outward toward the insulation, with power off, simply disconnect the element and remove it from the furnace. Rotate the element assembly 180° and reinstall. This will keep the element from embedding into the insulation and causing unnecessary degradation of both the element and the insulation.

3)* Chemical Attack - The heating elements will react with carbon monoxide, carbon dioxide and any other materials which will react with silica.

4)* When replacing broken Kanthal Super 33 heating elements, inspect fibrous ceramic insulation tabs on the element holders. Tabs should not be broken and should be the same length as the roof thickness in order to fill the void between element terminals completely. Replace broken or "attacked" tabs.

* On unprotected heating element surfaces, i.e., the high temperature portion of the element from which the protective silica glaze has flaked off, a yellowish powdery layer may form. This yellowish material is volatilized during the formation of the silica glaze which will form over the effected area at temperatures above 800°C and is not detrimental to the overall operation.

* Molybdenum disilicide (Mo Si02) elements only.

Serial # 870228

SPECIFICATIONS

☐ 2200 Series: Alumino Silicate fiber

1150°C continuous operating temperature
1200°C maximum operating temperature

☐ 2800 Series: Alumina fiber

1500°C continuous operating temperature
1550°C maximum operating temperature

☒ 1600 Series And ☐ 2900 Series: Alumina fiber

1600°C continuous operating temperature
1600°C maximum operating temperature

☐ 3000 Series: High density alumina fiber

1650°C continuous operating temperature
1650°C maximum operating temperature

☐ 1700S Series: High density alumina fiber

1650°C continuous operating temperature
1700°C maximum operating temperature

☐ 1700 Series: Zirconia fiber

1600°C continuous operating temperature
1700°C maximum operating temperature

FURNACE ASSEMBLY

CAUTION: Rapid Temp VTF furnaces should always be handled in an upright position. Never attempt to operate in any other position than with the heating element terminal ends pointing up.

Molybdenum disilicide elements are fragile at room temperature and must be handled with great care.

Zirconia insulation has poor mechanical strength and must be handled carefully.

1. Remove all packing material from furnace.

2. Remove cover by removing outer screws in cover marked "A" on assembly diagram.

3. Very carefully insert elements through roof sections. See assembly diagram.

4. Carefully attach straps and clamps to elements. See assembly diagram.

   CAUTION: Place straps on aluminized terminal end of heating element and form strap to element. Squeeze winged ends of clamps to open jaws and drop down over the strap, then release in place. Do not attempt to rotate strap or clamp on terminal with the clamp jaws closed otherwise elements may break due to torsional stress induced by the rotating motion.

5. Insert lead straps through the hole(s) in the back of the stainless steel cover or insulating block. Place cover on furnace and connect lead straps to brass power terminals. For best results, place end of wire from power supply directly against lead strap end before securing with washer and nut.

   NOTE: On 1520 and 1720 gas tight systems, connect lead straps to feedthru terminals (do not loosen transite bushings). Replace and bolt down sealing cover plate.

6. Insert thermocouples into the furnace and attach to terminals as indicated on assembly diagram.

7. Attach door to furnace. (Front loading models)

8. Insert tube. (HTF and VTF model)

WIRING OF CM INC POWER SUPPLIES

1. Remove shunt wire from thermocouple terminals of control instruments. Note; in some instances instruments do not require shunting and consequently the terminals will not be jumpered.

2. Connect compensated thermocouple extension wire to controller and control thermocouple terminal on furnace. Observe polarity. See Color Code below.

3. Connect compensated thermocouple extension wire to overtemperature instrument and overtemperature thermocouple terminal on furnace. Observe polarity. See Color Code below.

4. Connect #8 AVA wire to power terminals on furnace and to power supply terminals marked "TO FURNACE". (Polarity not required).

5. Attach appropriate power line to terminals of power supply. Tighten all connections and place terminal screen on furnace.

RED -

BLACK +

OPERATION OF CM INC POWER SUPPLIES

IMPORTANT: READ ALL INSTRUMENT MANUFACTURER'S INSTRUCTION MANUALS AND ENCLOSED LITERATURE BEFORE OPERATING THE POWER SUPPLY

TO TURN ON:

1. Set overtemperature at a higher point than the maximum process temperature (normally 25°C to 50°C higher), but not over 1600°C. (1700°C for 1700 Series)

2. Set current (power) adjust, located on temperature control instrument or on panel to zero.

3. Switch circuit breaker "ON".

4. Turn master switch "ON".

5. Set temperature control instrument and any auxiliary equipment such as programmers, timers, etc., in accordance with instrument manufacturer's instruction manuals.

6. Press "Reset" button located on overtemperature control instrument or on panel.

7. Setting for current (power) adjust can be used according to process requirements. Do not adjust beyond point which causes full scale deflection of panel current meter.

TO TURN OFF:

1. Turn master switch "OFF".

NOTE: As indicated in the chart, CM RAPID TEMP FURNACES ARE CAPABLE OF RAPID HEATING AND COOLING RATES IN ADDITION TO A MAXIMUM CONTINUOUS OPERATING TEMPERATURE OF 1550°C (1600°C for 1700 Series). However, the operating life of all RAPID TEMP FURNACES can be extended by limiting both the temperature cycling rate and the maximum temperature.

Slower heating rates may be obtained by manual setting of the current (power) adjust.

MAINTENANCE

CM Inc Rapid Temp furnaces are designed to be essentially maintenance-free. The following hints are given to obtain maximum service and life of components;

1500 SERIES

1. Both the primary insulation, alumina fiber, and the heating elements are fragile and should not be subjected to mechanical abuse.

2. Do not apply voltages to the elements which exceed that noted on the assembly diagram included in the Owners Manual.

3. The furnace should not be subjected to continuous duty temperatures in excess of 1550°C. Short runs of temperatures up to 1600°C can be accomplished by the system but will reduce the overall life of the furnace components. Conversely, lower temperature will extend the life of the system.

   NOTE: Surface cracks generally appear in the insulation when used above 1400°C and will be more profuse with higher temperatures or advanced age. These generally have negligible affect on the thermal insulating quality of the insulation.

4. Some elements exhibit a tendency to bow or curl along the heated length. If this curl is outward toward the insulation, simply disconnect the element, with power OFF, and remove it from the furnace. Rotate the element assembly 180°and reinstall. This will keep the element from embedding into the insulation and causing unnecessary degradation of both the element and the insulation.

5. Chemical Attack - The heating elements will react with carbon monoxide and carbon dioxide.

MAINTENANCE

1700 SERIES

1. Both the primary insulation, zirconia fiber, and the heating elements are fragile and should not be subjected to mechanical abuse.

2. Do not apply voltages to the elements which exceed that noted on the assembly diagram included in the Owners Manual.

3. The furnace should not be subjected to continuous duty temperatures in excess of 1600°C. Short runs of temperatures up to 1700°C can be accomplished by the system but will reduce the overall life of the furnace components. Conversely, lower temperature will extend the life of the system.

   NOTE: Surface cracks generally appear in the insulation when used above 1400°C and will be more profuse with higher temperatures or advanced age. These generally have negligible affect on the thermal insulating quality of the insulation.

4. Some elements exhibit a tendency to bow or curl along the heated length. If this curl is outward toward the insulation, simply disconnect the element, with power OFF, and remove it from the furnace. Rotate the element assembly 180° and re-install. This will keep the element from embedding into the insulation and causing unnecessary degradation of both the element and the insulation.

5. Chemical Attack - zirconia fiber insulation will react with gaseous halides in the presence of a reducing agent such as carbon or carbon monoxide at elevated temperatures. It may react with silica-containing materials and form low melting temperature solutions and compounds. The heating elements will react with carbon monoxide and carbon dioxide.

MAXIMUM ELEMENT TEMPERATURE FOR KANTHAL SUPER ELEMENTS IN DIFFERENT ATMOSPHERES:

ATMOSPHERE	MAX. ELEMENT TEMP. °C	°F
Air	1800	3272
Nitrogen	1600	2900
Sulphur Dioxide	1600	2900
Carbon Dioxide	1600	2900
Carbon Monoxide	1500	2730
Argon	1500	2730
Helium	1500	2730

NOTE: 1800°C IN AIR REFERS ONLY TO THE MAXIMUM ELEMENT TEMPERATURE.

CM FURNACES INC.
103 Dewey Street, Bloomfield, New Jersey 07003
Area Code (201) 338-6500

"INSTRUCTIONS FOR ASSEMBLY BOTTOM LOADING RAPID TEMP FURNACE"

Front of furnace has the observation port and large CM label. The power lift front has the control panel - orient sections to align these parts.

Remove four screws from tabs on top of power lift. Place furnace on top of power lift and make sure all four holes line up with holes in tabs. It is important you install all four screws for proper alignment.

Connect line cord to 115 VAC grounded receptacle. Turn power switch on, set selector switch to "UP" position, run lift at its slowest speed. Observe lift going up into furnace for alignment. There is a limit switch that will stop lift at its proper height. Position selector switch in "DOWN" position. This will allow lift to come down; it will also be stopped by a limit switch.

Note: All switches are factory set and should not require further adjustment.

CM FURNACES INC.
103 Dewey Street, Bloomfield, New Jersey 07003
Area Code (201) 338-6500

RECOMMENDED SPARES

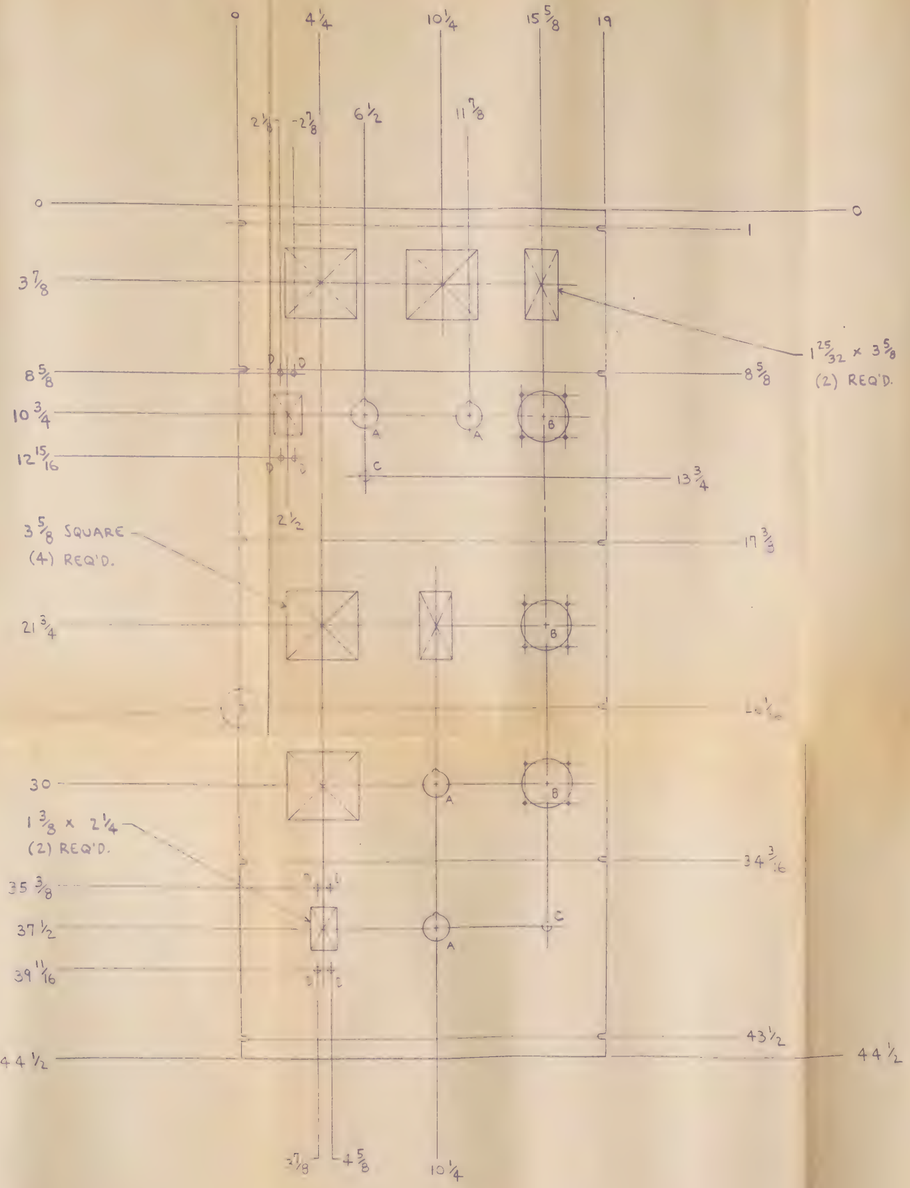
ITEM	DESCRIPTION
1.	Heating Element Assembly - Kanthal Super 33 Bd-2038 - Heating Element Assembly
2.	Thermocouple type "B" 1600 Series: #H-499-4
3.	Fuses for SCR Power Control Unit

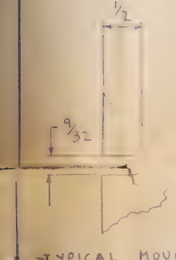
CM Inc. High Temperature Industrial and Laboratory Furnaces
103 DEWEY STREET BLOOMFIELD, NEW JERSEY 07003 201/ 338-6500

DRAWING LIST

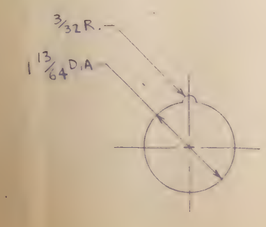
Ad-1155 Furnace Assembly
Gc-2342 Schematic
Gd-2387 Panel Layout

SHEET 1 OF 1 | SIZE D | Gd-2387 | REV

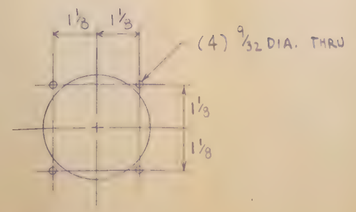




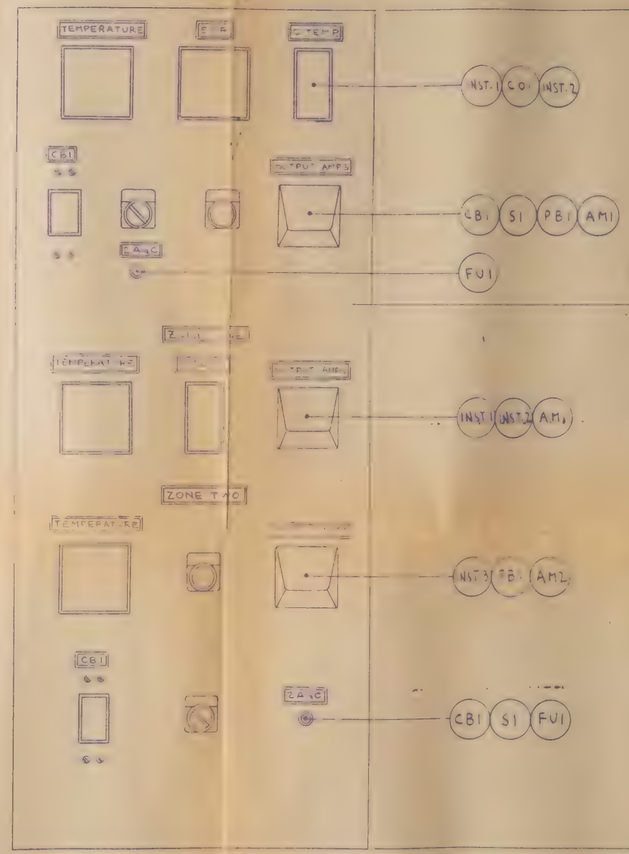
TYPICAL MOUNTING HOLE DIMENSIONS (6) EACH SIDE FULL SCALE



DETAIL "A"
FULL SCALE



DETAIL "B"
1/2 SCALE



SCHEMATIC GC-2342

SCHEMATIC GC-2345

NOTE:
PRIME, THEN PAINT WITH TWO COATS OF SHERWIN WILLIAMS ENAMEL # F68A2 MEDIUM GREY

D	3/16 DIA.	5
C	1/2 DIA.	2
B	SEE DETAIL "B"	3
A	SEE DETAIL "A"	4

HOLE SCHEDULE

SCHEMATIC REFERENCE DRAWINGS: 870228 & 870247

REV	DESCRIPTION OF CHANGE	BY	DATE	AP

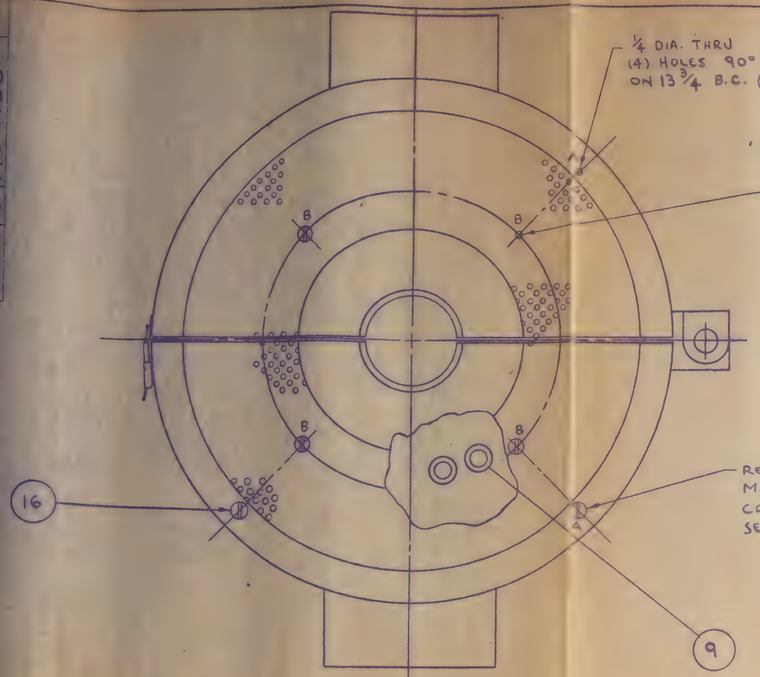
UNLESS OTHERWISE SPECIFIED
FRACTIONS | DECIMALS | ANGLES

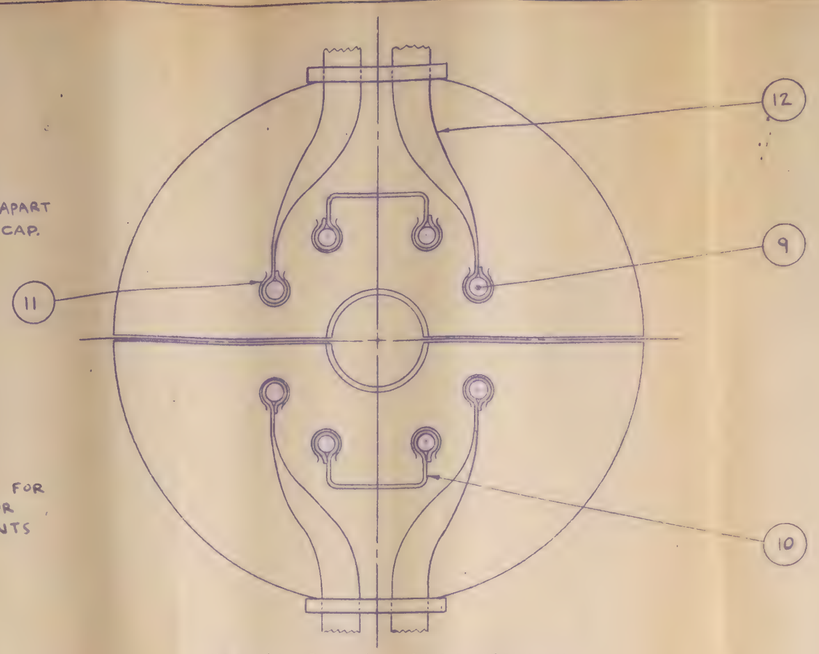
DUAL PANEL LAYOUT

CM INC
100 DEWEY ST BLOOMFIELD NJ

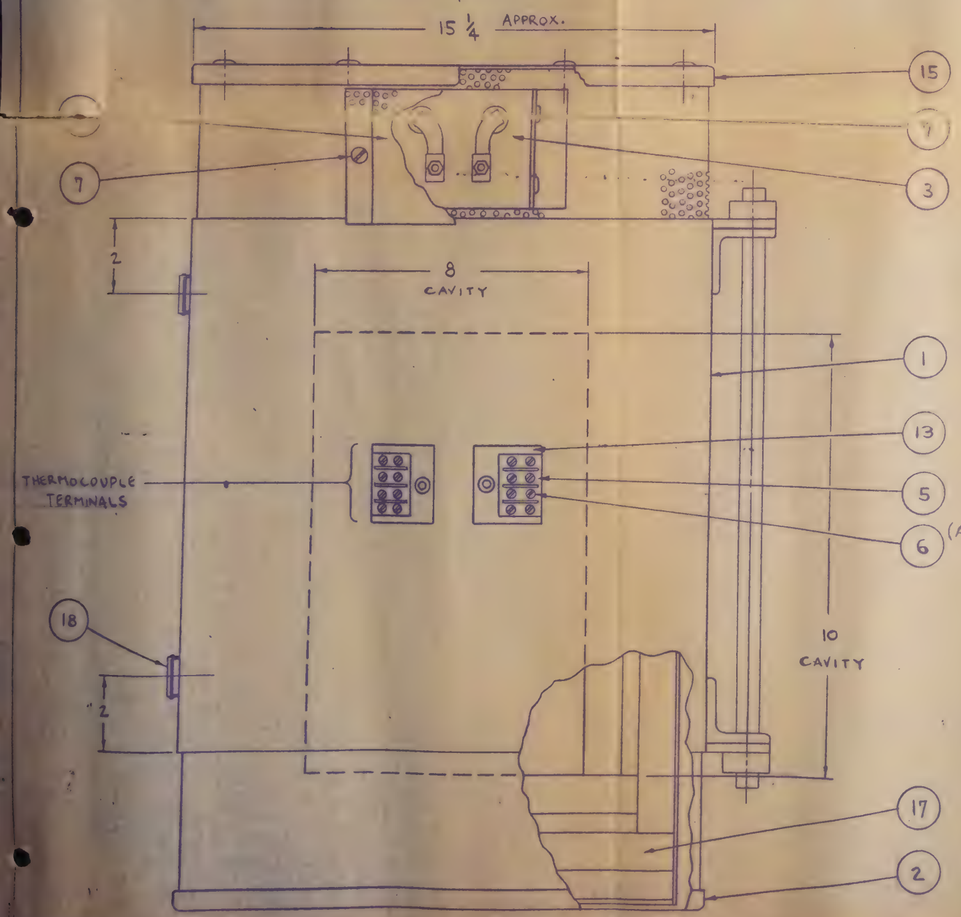
DRN FW | DATE 5/6/87 | SCALE 3/4 - 0" | APP | DATE | SCALE | SHEET 1 OF 1 | SIZE D | Gd-2387 | REV A

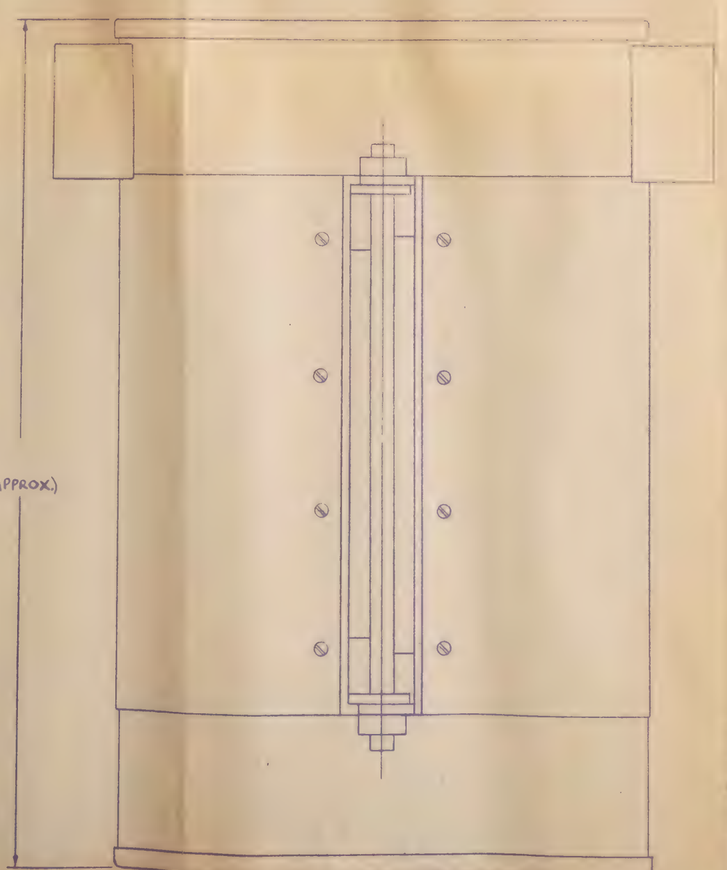
1 of 1 | D | Ad-1155





HEATING ELEMENT INTERCONNECTIONS





BILL OF MATERIAL

ITEM	PART NO.	DESCRIPTION	QTY.
1	Bd-2034	SHELL, FURNACE	1
2	Bd-2034	END CAP, FURNACE (ALTER PER SHELL DWG.)	1
3	Mb-428-1	TERMINAL BLOCK, POWER	2
4	H-483	SHIELD, PROTECTIVE	2
5	10,009-2	TERMINAL BLOCK, THERMOCOUPLE	2
6	COMM.	SCREW #6-32 X 1/2 TAPPING SCREW PAN HD.	8
7	COMM.	SCREW #6-32 X 3/8 PAN HD.	12
8	COMM.	SCREW #10-32 X 1/2 PAN HD.	8
9	Bb-2038	HEATING ELEMENT ASSY.	6
10	M-386-8	STRAP, TERMINAL	2
11	10,003-B-T	CLAMP, TERMINAL	8
12	M-385-10	STRAP, EXTERNAL CONNECTING	4
13	Mb-428-2	INSULATING SPACER	2
14			
15	Bb-1511-15-6	END CAP, FURNACE, ALTER PER SHELL DWG.	1
16	COMM.	#10 SELF TAPPING "B" TH'D, ROUND HD., ST. STL.	8
17	Bd-2035	REV. 1 INSULATING DIAGRAM	1
18	COMM.	LATCH, NIELSON #36-B-83314-42 ST. STL.	2
19			
20			

QTY	DESCRIPTION	REFERENCE DRAWINGS
	Bd-2034 FURNACE SHELL	
	Bd-2035 INSULATION DIAGRAM	

HOLE SCHEDULE

SYMBOL	TIME	WEIGHT	FIRST USED
			870228

REV	DESCRIPTION OF CHANGE	BY	DATE	SH

TOLERANCE UNLESS OTHERWISE SPECIFIED

FRACTIONS | DECIMALS | ANGLES

FURNACE ASSEMBLY
RAPID TEMP. 1600 VTFS (C)

CM FURNACES
108 DEWEY ST. BLOOMFIELD N.J. 07003

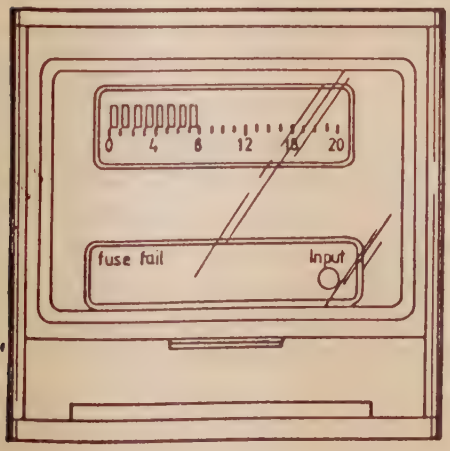
DRN.	DATE	SCALE
FH	8/4/87	N.T.S.
CKD	DATE	SHEET
		1 OF 1

SIZE D | Ad-1155 | A

EUROTHERM

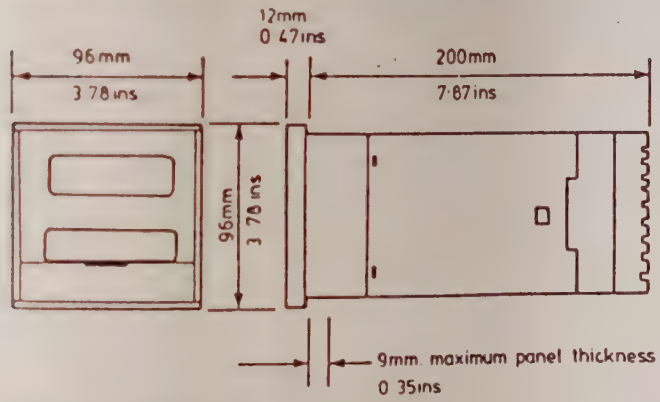
PANEL MOUNTING THYRISTOR UNIT TYPE 831

INSTALLATION AND OPERATING INSTRUCTIONS



Part No. HA018927

INSTALLATION AND DIMENSIONAL DETAILS



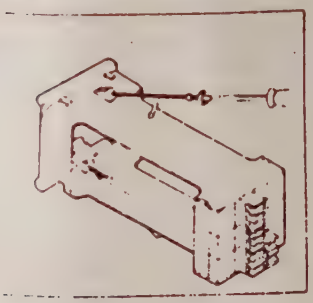
Panel cutout

3 62 $^{+0.03}_{-0.00}$ ins sq

92 $^{+0.8}_{-0.00}$ mm sq

INSTALLATION

The instrument plugs into a panel mounting sleeve which requires a DIN size 92 x 92mm cut out as illustrated. Remove the instrument from the sleeve by opening the front panel door and with a screwdriver turn the screw, in the bottom right-hand corner, counter clockwise. The instrument will start to withdraw from the sleeve and once the screw has been turned to its furthest extent the instrument can be withdrawn by hand. Remove the top and bottom mounting clamps from the sleeve by gently levering outwards and easing downwards inside the sleeve. Insert the sleeve through the cut-out via the front of the panel. Fit the mounting clamps in the slots from inside the sleeve and from the rear of the mounting panel tighten with a screwdriver.



By hand ease the instrument into the sleeve to its furthe extent. With a screwdriver turn the screw in the bottom right-hand corner clockwise until tight. The instrument will be pulled completely into the sleeve, engaging the rear terminals and be fully secured.

Note: Do not attempt to dismantle the instrument without referring to the Maintenance Manual.

Connections and Wiring

Electrical connections are made via terminals blocks on the rear of the unit. Wire size for lig current is 16 x 0.2 and for high current 10 to 40A is 6 — 16mm².

Supply Connection

Terminal 1 must be connected to Line 1. One end of the load must be connected to terminal while the other end of the load is returned to Neutral (L2). Terminal 3 must be connected Neutral (L2).

Control Signal Input

The signal from a controller should be connected to terminals 5 and 6. The correct polarity this supply must be observed i.e. terminal 5 is positive and terminal 6 is negative. The inp signal must be either a logic signal 0 — 30V dc for option 137, or an analogue signal 4 — 20r dc for option 073. The front panel "INPUT" LED illuminates when the input signal is appli

Current Limit

This option is only available with the phase angle firing mode. The current limit control located behind the front flap. It should be set initially to minimum and power applied to t system with 100% power called for. The current limit control can then be turned clockw towards "MAX" until the desired rms current is indicated on the display.
Terminal 4 provides the current feedback signal for connection to the controller, where initiates current limit. The signal is a full-wave rectified phase-angle waveform of 7V peak peak at full rated rms current with the current limit control set to 'MAX'. If set to 'MIN', peak to peak is produced at about one fourth full rated rms current.

Display

The optional 20 segment front panel meter indication displays true rms current in the ph angle firing mode, and average current in the zero crossover fast cycle mode.

Load Test Push Button

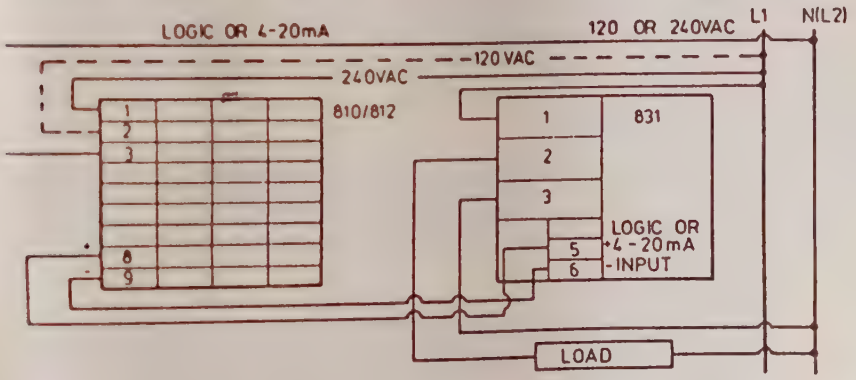
Located behind the panel flap, this button turns the output full on so that, at start-up, t current can be noted for future inspection when checking the load, and to set current lir With current limit set, it will deliver 100% of the limited current.

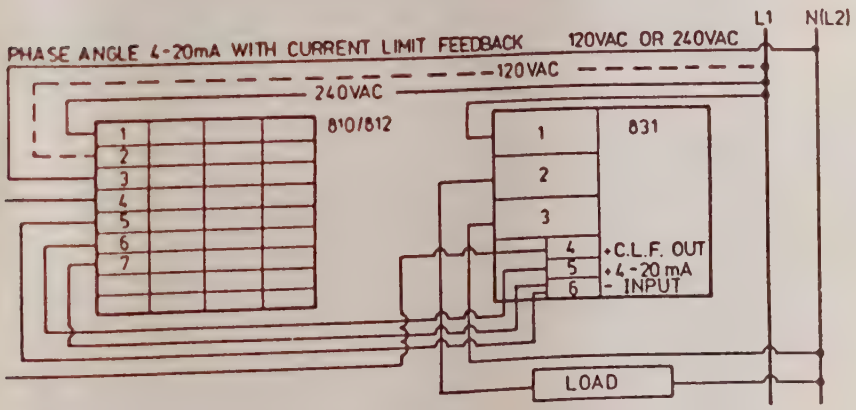
Fuse Rating and Access

If the load fuse fails, indicated by the illumination of the front panel Fuse Fail lamp, disconn the supply from the thyristor unit and unplug it from its sleeve. The fuses are located behin snap-on cover at the side of the unit. The load fuse F1 is the large one on the control boa Fuse F2 is in the L2 line to the instrument. Fuse F3, when fitted, is in series with the inp signal. Replace the faulty fuse with correct replacement type as indicated in the table belo Do not use any other type or fuse wire as this will almost certainly cause considerable dama to the unit the next time a short circuit load fault occurs. The use of any other fuse than th recommended in the table will invalidate the guarantee.

Fuse Value	10A	20A	30A	40A
Semikron Manufacturers Part No.	A025FA010Z	A025FA030Z	A025FA040Z	A025FA0

TYPICAL WIRING SCHEMES





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Telex 87114 EUROWG G

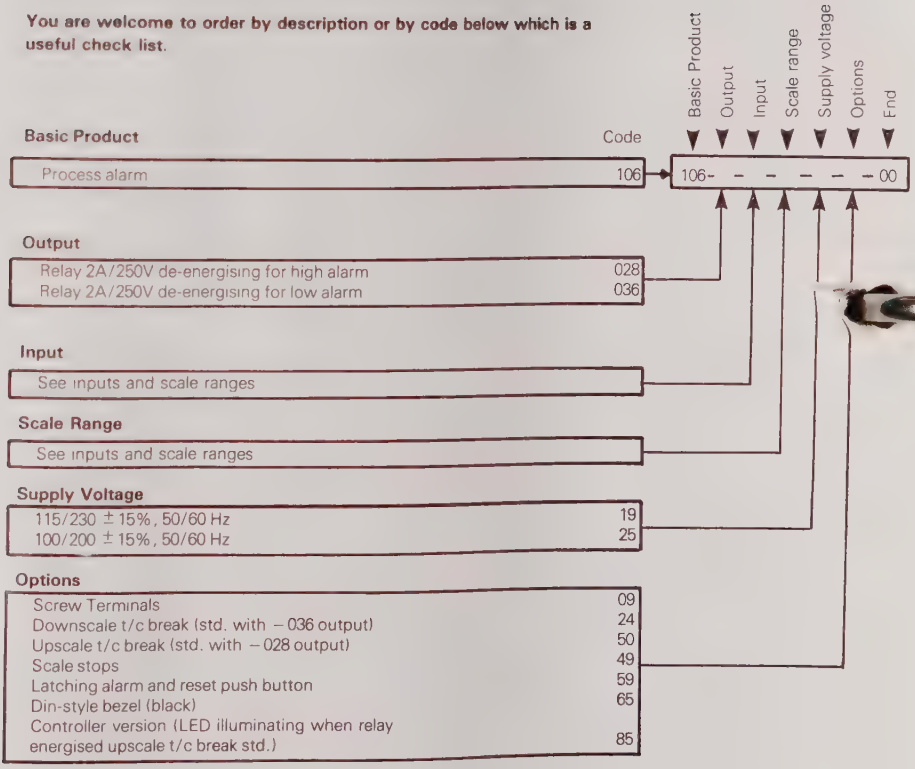
Printed in England 0884

EUROTHERM

ON/OFF CONTROLLER (PROCESS ALARM)
TYPE 106
INSTALLATION AND OPERATING INSTRUCTIONS

Ordering Information

You are welcome to order by description or by code below which is a useful check list.

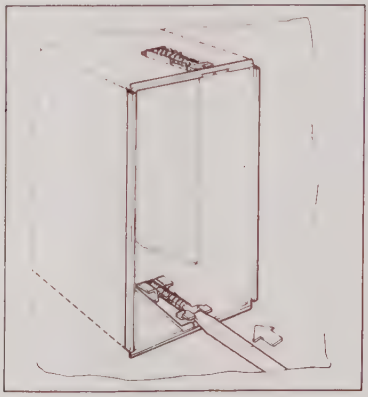


| Input Types | | Code | Degree Scales | | |

INSTALLATION

The instrument plugs into a panel-mounting sleeve which requires a DIN-size 92 × 45mm cut-out. Remove the instrument from the sleeve by opening the door and pulling on the door handle.

As sleeve insertion and retention is done from the front of the panel, rear access is not required. All wiring to the sleeve could therefore be carried out beforehand.

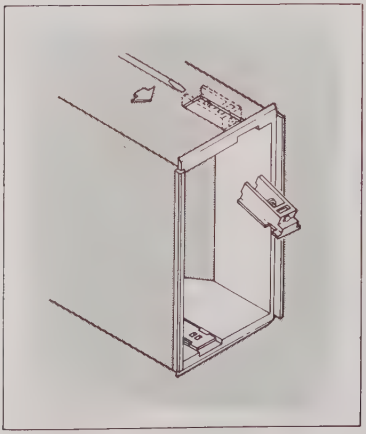


Spring Clamp Version

Remove each spring-loaded clamp by placing a screwdriver blade (ideally between 4mm and 6mm wide) under one or both of the front prongs inside the sleeve. Push towards the rear until it is possible to lift the clamp inwards. Gently release the pressure on the spring.

Fully insert the sleeve into the cut-out with the open section to the right. Replace the two clamps by locating the rear of each in the slot as shown in the diagram below. As before, with a screwdriver blade push the front of the clamp towards the rear until the centre prong clears the front edge of the slot. The clamp may then be released into place, ensuring that the two prongs on the inner surface of the sleeve are flush with that surface.

Plug the instrument into the sleeve by inserting with the door open and pushing fully home. The act of shutting the door locks the instrument in place.



Screw Clamp Version

For screw clamp version access is required from the rear of the panel. Insert sleeve into panel aperture, then snap-fit clip into sleeve as shown in diagram. The mounting screw can then be adjusted to clamp to the back of the panel.

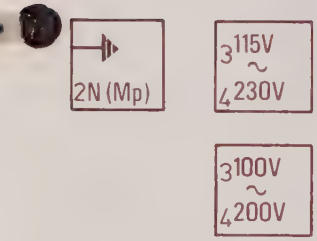
Note: Allow adequate space above and below the instrument for free air circulation such that the local air temperature does not exceed 55°C. Therefore do not mount instruments closely above one another or in confined spaces.

CONNECTIONS AND WIRING

Electrical connections are made via either 2·5mm screw clamps or ¼" double faston terminals recessed in the rear of the sleeve. For instruments fitted with screw clamps, before inserting the wires in the terminal block ensure the screws are undone sufficiently to allow the wire to be positioned correctly. A 0·5sq.mm (or equivalent) wire size is adequate for low-current connections (up to 2A)

A label adjacent to the terminals identifies input, output and supply connections. The terminals are numbered 1 to 13, starting from the top.

Supply



The instrument supply is connected between neutral (N(Mp)) and the relevant live terminal, as detailed by the instrument label. The ground connection is made to terminal 1.

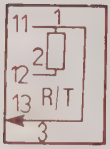
INPUTS

Thermocouple

Thermocouple connections are made to the terminals 11 and 12 as shown. Compensating cable of the correct type must be used between the thermocouple and the instrument and must be connected in the correct polarity. To check compensating cable polarity, disconnect the cable from the thermocouple, twist the bare ends together and apply heat to the junction. With the instrument set point at about ambient, the error-indicating LED's should show an increase in temperature. The total length of thermocouple and compensating cable used is not critical but the loop resistance should not exceed 100Ω.

Thermocouple break protection is standard as upscale for a −028 output and downscale for a −036 output.

Resistance Thermometer (100 Ohm)

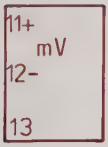


Platinum resistance thermometer (RT) connections are made to terminals 11, 12 and 13 as shown. Generally, a 3-wire heavy duty RT has the terminal block on its head numbered as in the diagram whilst a standard type has two blue leads (equivalent to 1 and 3) and one red lead. If a 2-wire RT is used, connect to the instrument as terminals 11 and 12 and link terminals 11 and 13. Copper wire should be used throughout.

RT break protection is available as upscale only, on only 2 out of 3 wires; a 2-wire RT is fully protected for upscale break protection. Downscale break protection is not possible.

Note: In 2-wire RT's, every 1Ω of cable loop resistance gives an error of about 2.6°C.

Millivolt Input



The positive and negative wires of a millivolt input are connected to the instrument as shown, using copper wire.

OUTPUT

Either of two types of output are available, each having the relay contacts brought out on terminals 5 (common), 6 (n/o) and 7 (n/c). The relay is rated at 2A, 250V a.c. with the n/o contact being suppressed with a 0.022μF capacitor and a 100Ω resistor. The alarm state LED is off when the relay is energised (unless option −85 is called for).

Type −028 output
The relay gives protection against over temperature conditions in which the relay de-energises in alarm (above set point) and an open circuit thermocouple or RT gives upscale break protection. This is the type normally used when the instrument is to function as a controller.

Type −036 output
The relay gives protection against under temperature conditions in which the relay de-energises in alarm (below set point) and an open circuit thermocouple gives downscale break protection.

OPTIONS

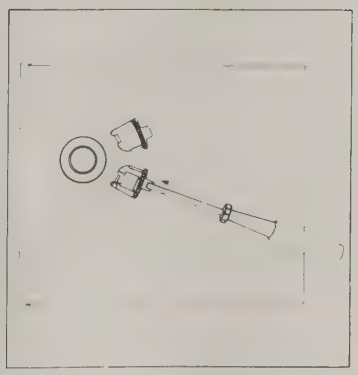
Scale Stops: (Option −49)

Instruments ordered with scale stops are delivered with both stops, each set at zero and span.

To set a stop so that it is not possible to rotate the scale drum above a certain temperature, turn the set point to span, insert a narrow screwdriver into the lower of the two cut-outs located in the metal cover (as shown in the diagram below) and lever the plastic moulding away from the scale drum. Holding the stop thus, turn the set point to the required maximum temperature and release the stop ensuring it is fully engaged in the drum.

A similar procedure is followed if a minimum temperature limit is required; rotate the drum to zero, disengage the stop in the upper cut-out, turn the set point to the required minimum temperature and release the stop.

Care must be taken not to exert too much leverage on each scale stop with the screwdriver.



Scale Stop Adjustment

Latching Alarm and Reset Push Button: (Option −59)

For fleeting alarms, this option is available. Upon an alarm occurring, the relay de-energises. Upon the alarm situation clearing, the relay remains in the de-energised state and is reset by pushing the button located behind the front door; the relay then becomes energised through its own latch-in contact.

Alarm State LED on when Relay Energised: (Option −85)

This LED logic is recommended when the instrument is used as a controller rather than a process alarm.

ADJUSTABLE CONTROLS

Temperature Setting

Set the required alarm temperature (say) by rotating the set point drum behind the instrument door. In the case of the alarm point being considerably higher than the load temperature, upon connecting the supply the lowest error-indicating LED will light showing that the temperature is more than 3% of span downscale; a small arrow masking the LED indicates this. The relay will be either energised (output −028) or de-energised (output −036); the alarm state LED will be off or on respectively.

As the temperature approaches the alarm point, the next error-indicating LED will light showing that the temperature is between 1% and 3% below the alarm point. When the temperature finally reaches the alarm point ±1%, the centre LED will be illuminated. Should the temperature go above the alarm point, one of the two upper error-indicating LED's will be illuminated to indicate errors of 1% to 3% or greater than 3% above the alarm point, the upper LED also being masked by a small arrow as before.

Upon the temperature passing through the alarm set point, the relay and alarm state LED will change to their opposite state.

Deadband Adjustment

A deadband potentiometer is located on the top edge of the instrument case, and is accessed by unplugging the instrument. The range of control is variable between 0.2% and 2% of span, the de-energise (alarm) point being unaffected with deadband variation.

When the instrument is used as a controller and option −85 is called for, the action of the alarm state LED is inverted (i.e. on when the relay is energised.)

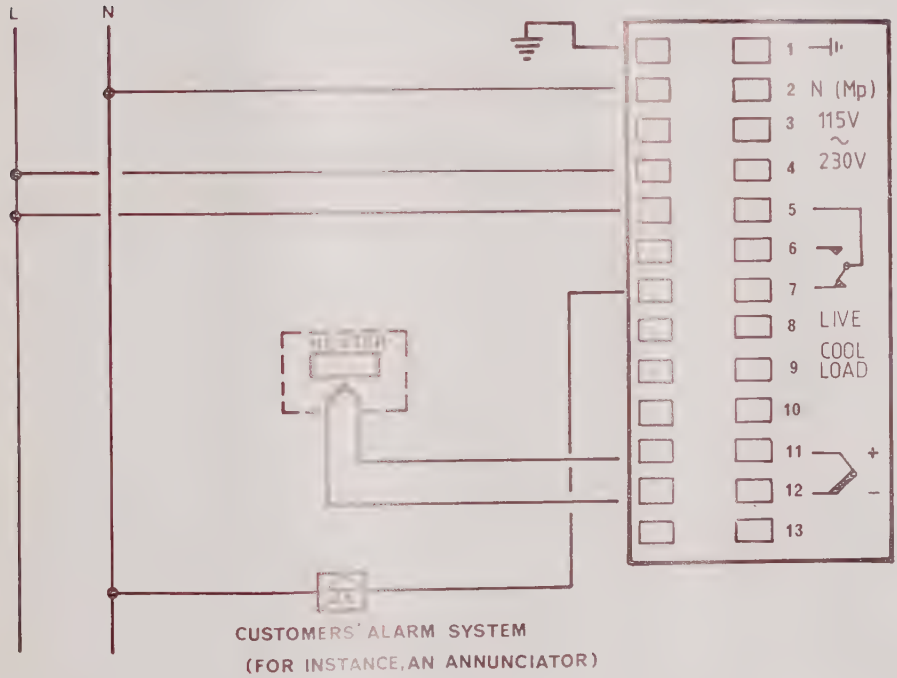
Controller Type 106 Fault Finding Guide

CONDITION	FAULT	ACTION
All LED's extinguished	a. Break in supply connections.	a. Repair supply connections.
	b. LED board failure (will not interfere with control)	b. Replace LED board — see maintenance manual or contact Eurotherm.
	c. Transformer failure. To check, monitor voltage on alternative supply terminal. Absence of voltage indicates transformer failure.	c. Check cause of failure if possible, & replace transformer — see maintenance manual or contact Eurotherm.
	d. Failure of IC2.	d. Replace IC2.

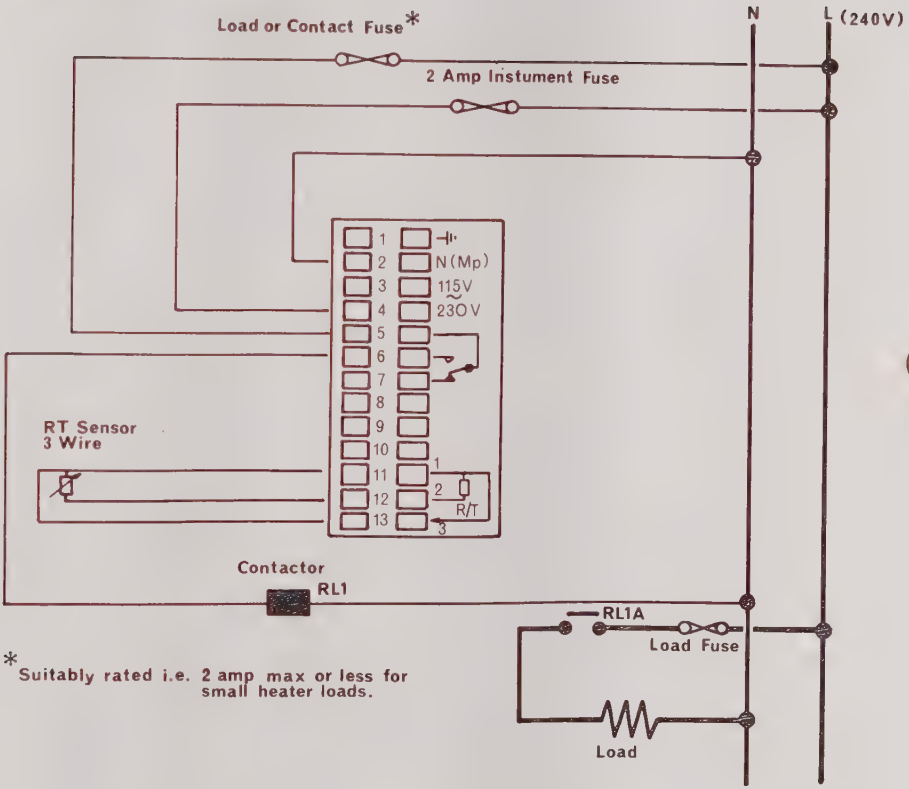
NOTE — If a fault is suspected in the thermocouple or thermocouple interconnections, this can be confirmed as follows:- Disconnect the compensating cable from the instrument thermocouple terminals and connect a millivolt source to these terminals. Check that the instrument LED indicator moves up and down the scale as millivolt signals corresponding to temperatures above and below the set point are injected. If the LED indicator fails to respond in this manner, an internal fault exists in the instrument.

Typical Wiring Schematic

106 Alarm Unit (– 028 or – 036 output)



106 wired as Controller



* Suitably rated i.e. 2 amp max or less for small heater loads.

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EUROTHERM EUROTHERM EUROTHERM

OPERATION AND MAINTENANCE MANUAL FOR

MICROPROCESSOR BASED 3 MODE CONTROLLER

MODEL 810

EUROTHERM CORPORATION
A EUROTHERM INTERNATIONAL COMPANY
11485 Sunset Hills Road, Reston, Virginia 22090 ☐ Telephone: (703) 471-4870 ☐ Telex: 89-9449

CAUTION

Before installing, operating, or servicing equipment supplied by Eurotherm Corporation, please read the following:

INSTRUCTIONS FOR SAFE USE OF EUROTHERM EQUIPMENT

(Note: These instructions represent good engineering principles and are applicable to all control equipment of the same type, whether from Eurotherm or any other supplier.)

OVERCURRENT PROTECTION

It is recommended that A.C. power supplies to Eurotherm instruments be protected by fuses or automatic circuit breakers rated at not more than 2 amperes.

Each Output circuit should be protected by line fuses or automatic circuit breakers rated at the same current and voltage as the output device.

Note: Fuses fitted to Eurotherm Thyristor (S.C.R.) Units are for protection of the internal components only. They are not intended to replace normal line fuses. All installations using Eurotherm Thyristors or Triac units must be equipped with line fuses of appropriate ratings.

Note: The "Current Limit" feature (available as an option on some Eurotherm equipment) is not a substitute for fuses. This feature is provided to accommodate the variation in load resistance of some types of electric heating elements. It provides no protection against excess current due to insulation failure or short circuits, and suitable fuses must be provided in all cases.

VOLTAGE RATINGS

Care must be taken to ensure that maximum voltage ratings are not exceeded.

Unless otherwise stated in the specification of any particular unit, the maximum voltage which may be applied between any two isolated circuits, or between any isolated circuit and ground is limited to the highest rated supply voltage for that unit.

ENCLOSURE OF LIVE PARTS

Some metal parts of certain types of Eurotherm equipment can become electrically 'live' in some conditions of normal operation, (for example: cooling fins on some thyristor units).

Unless clearly intended to be panel mounted and accessible during normal operation, all units should be installed inside a suitable grounded metal enclosure to prevent live parts being accessible to human hands and metal tools.

It is recommended that rear terminal covers (available as an option on most Eurotherm units) be fitted wherever possible.

WIRING

It is important to connect all equipment correctly in accordance with the installation data provided for each type of unit.

Unlabelled terminals must not be used as "tie points" for other wires (unless the installation instructions mention that this is permissible). Such unlabelled terminals may be internally connected. Any questions concerning the correct wiring of a Eurotherm unit should be directed to the nearest Eurotherm Sales and Service representative.

Most connections to Eurotherm equipment require correct polarity to be maintained, and due attention must be given to ensure this.

Wiring should conform to appropriate standards of good practice and local codes and regulations. Conductors should be commensurate with voltage and current ratings of the units.

GROUNDING

All "Ground" terminals must be securely connected to ground by conductors appropriate to the current ratings of the units.

Most Eurotherm controllers have internal circuits which are isolated or "floating." This is necessary to prevent the occurrence of "ground loop" in signal circuits. To avoid possible shock hazards in the event of an internal fault causing breakdown of insulation, it is recommended that all equipment connected to any Eurotherm unit be enclosed in a grounded metal enclosure. Sheaths of thermocouples (or other sensors) should be properly grounded by a separate conductor (instead of being dependent on grounding via the machine framework).

OUT-OF-LIMITS ALARMS

In applications where excessive deviation of a controlled parameter due to equipment failure could cause damage to machinery or materials, or injury to personnel, it is recommended that an additional separate unit be used to give alarm indication or to shut down the process or both, as may be appropriate. (Note: 'Alarm boards' fitted inside controllers may not give sufficient protection in these circumstances). When 'alarm units' or 'alarm boards' are used they should be checked for correct operation and calibration at regular intervals.

SUPPLY ISOLATORS

Every electrical system should be provided with means for isolating the system from the A.C. supply to allow safe working during repair and maintenance. S.C.R.'s and Triacs are not adequate means of isolating the supply, and should always be backed by a suitable mechanical disconnect switch.

HAZARDOUS ATMOSPHERES

Unless otherwise stated in the published specification of any particular unit, Eurotherm products are not suitable for use in areas subject to hazardous atmospheres. No Eurotherm product should be connected to a circuit which passes into or through a hazardous area unless appropriate precautions are taken (even though the controller itself may be located in a safe area). Such an installation should conform to the requirements of the relevant Authority. (In USA: Factory Mutual Research Corporation and Underwriters' Laboratories Inc.)

PROCEDURE IN THE EVENT OF FAILURE

Before beginning any investigation of a fault, the electrical supplies to all equipment concerned should be switched off and isolated. Units suspected of being faulty should be disconnected and removed to a properly equipped workshop for testing. Any attempt to trouble-shoot while installed could be hazardous to personnel and equipment.

IF IN DOUBT, ASK!

If you have any questions regarding any aspect of installing, operating or servicing your Eurotherm equipment, please contact your nearest Eurotherm Sales and Service Representative.

EUROTHERM CORPORATION
A EUROTHERM INTERNATIONAL COMPANY

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SECTION I

INTRODUCTION

1.1 Scope

This manual contains installation, operation and maintenance instructions for Eurotherm Model 810 Microprocessor Based Controller, herein referred to as the Controller (figure 1.1). Additionally, this manual includes an illustrated parts list, identifying replaceable piece parts, subassemblies and assemblies. Lastly, a product brochure, summarizing Controller specifications, ordering data and warranty information is included as an attachment at the end of this document.

1.2 Purpose and Use

The Temperature Controller is a compact high performance temperature control unit, designed for industrial and laboratory applications where precision temperature control conditions are required.

Figure 1.1: Eurotherm Model 810 Microprocessor Based Controller

SECTION II

DESCRIPTION AND DATA

2.1 General Description

The Temperature Controller is a microprocessor based, solid state, compact, three mode (proportional, integral and derivative) instrument, featuring a digital readout and a wide range of interchangeable outputs, temperature ranges and sensor types.

Controller inputs can be either thermocouple or resistance temperature detector (RTD), milliampere, or millivolt signals fed from special sensors. Thermocouple break protection and cold junction compensation are standard on all thermocouple input types.

Precise temperature settings are assured through the use of RAISE and LOWER pushbuttons and a unique digital display. The digital display is a customized fluorescent indicator panel composed of a nine segment error bargraph, to give an analog indication of proximity to setpoint, and four, seven segment indicators giving accurate indication of process variables.

The configuration of the specific controller in terms of range, input type, alarm configuration, linearization, etc. is held in electrically alterable read only memory, EAROM. In the event of power loss, this device employs charge storage characteristics to retain this specific information.

Plug-in circuit boards for input, output and optional alarm functions enable operational versatility, ease of maintenance and reconfigurability. Table 2-1 lists all of the circuit boards that may be installed in the Controller. All output boards are interchangeable, and input ranges can be changed by re-programming or by exchanging the characterizing EAROM.

The controller is ruggedly constructed and physically housed in its own panel mounting sleeve which requires a 3.62 inch square cutout. The instrument measures 7.88 inches deep.

All external connections are made on the terminal block located on the back of the instrument. A label containing connection information, model number and serial number is placed on top of the mounting sleeve.

2.2 Optional Equipment

Electrical and mechanical options available with the controller are referenced in the attached data bulletin.

2.3 Technical Characteristics

Pertinent technical characteristics for the controller are listed in Table 2-2. Refer to the product data bulletin for additional information.

2.4 Special Test Equipment

Special test equipment required to operate and maintain the controller is referenced in Table 2-3. Similar equipment may be used providing operation and maintenance performance is not degraded.

Table 2.2: **Technical Characteristics**

CHARACTERISTICS	SPECIFICATIONS
Ambient Temperature	0-50°C (32-122°F)
Line Voltage	105/210 VAC ± 10% 120/240 VAC ± 10% 85-264 VAC switch mode power supply
Line Frequency	48-62 Hz
Relative Humidity	0-90% Non-Condensing
Input Common Mode	300 VAC RMS maximum with respect to ground
Input Series Mode	Greater than 1000:1 (60db) giving no observable effect for up to 50mV RMS.
Power Consumption	10 VA Maximum
Setpoint Resolution	1° or 1 least significant digit
Maximum Thermocouple Resistance	100 ohms
Input Signals	Thermocouple or RTD, Milliampere, Millivolts
Deviation Indication	Vertical 9 segment bargraph display, ± 0.5% to 5% of instrument span
Calibration Accuracy	± 0.25% of instrument span
Proportional Band	Adjustable in steps from 0.5% to 100%
Integral (Reset)	Adjustable in steps from 15 to 1800 seconds with integral OFF
Derivative (Rate)	Adjustable in steps from 5 to 600 seconds with derivative OFF
Overall Dimensions	3.78 in. W x 3.78 in. H x 7.88 in. deep Panel cutout 3.62 in. square
Weight	2.42 lbs.
Display Size	0.500 inch high, 7 segment fluorescent display
Data Retention	Minimum 10 years with instrument unpowered. Typically 1 year with 10,000 erase/write cycles

Table 2-3: **Special Test Equipment**

NOMENCLATURE	MFR. AND MODEL	OPERATING RANGE
Millivolt Source	Eurotherm Model 239 Millivolt Source	0.0-59.99mV CJC compensated for R, S, K, J, E and T Thermocouples
Voltmeter		

Table 2-1: Major Subassemblies

Nomenclature
MOTHERBOARD ASSEMBLY
POWER SUPPLY/CHANNEL 1 OUTPUT BOARD
MICROPROCESSOR BOARD
CHANNEL 2 OUTPUT/ALARM BOARD (FSH, FSL, HL, LL, DL)
REMOTE ANALOG SETPOINT BOARD (RLS, RLT, MVO)
INPUT BOARD
ISOLATED D.C. SUB-BOARD A
ISOLATED D.C. SUB-BOARD B

SECTION III

PRINCIPLES OF OPERATION

3.1 Scope

This section contains the electrical principles of operation for the Temperature Controller. The discussion is keyed to an exploded view drawing, figure 3-1, illustrating the Controller in disassembled form and to a functional block diagram, figure 3-2, which shows the interrelationship of the Controller's subassemblies and components. To facilitate understanding of the Controller, a brief description of each assembly is provided.

3.2 Motherboard

The motherboard contains sets of pins for the connection of the various plug-in assemblies. With the exception of the input board and the isolated D.C. sub-boards, all other assemblies plug into the motherboard. Also, the motherboard is composed of a custom fluorescent indicator panel (FIP) containing four seven-segment indicators and a nine-segment error bargraph, a RAISE pushbutton, a LOWER pushbutton, a PARAMETER SCROLL pushbutton, a REMOTE/LOCAL pushbutton if fitted, and alarm and output LED indicators.

3.3 Power Supply/Channel 1 Output Board

The power supply/channel 1 output board contains the power supply circuitry that develops all the required voltages for the Controller, and it contains the necessary circuitry to develop the desired heat output signal. This board also contains the power feedback and mains fail detection circuitry.

The power feedback circuitry is designed to approximate a V^2 power controller. Should the microprocessor detect an A.C. power supply change, the microprocessor will adjust the output stage cycle time in order to retain the same output power level. The mains fail detection circuitry is designed to detect an A.C. power failure and alert the microprocessor. The microprocessor then ensures that all relevant circuitry is placed in a safe state.

3.4 Microprocessor Board

The microprocessor board contains the Controller microprocessor, the Dual Slope analog-to-digital converter circuitry, the watchdog circuitry, and the EAROM.

The microprocessor controls all the major functions of the Controller. The microprocessor continually updates the display, handles all operational changes via the RAISE, LOWER, and PARAMETER SCROLL pushbuttons, controls the A/D conversion, implements the 3-term control algorithm, controls the output stages, and checks for alarms.

The A/D converter circuit accepts an analog input signal and digitizes the signal for use within the microprocessor. The EAROM provides non-volatile storage of operational parameters such as control setpoints and control parameters. The watchdog circuit develops a reset signal for the microprocessor should a fault occur, and it also ensures that the microprocessor is placed in the correct state of operation on power-up or power-down. See figure 3-3 for a functional block diagram of the microprocessor.

3.5 Channel 2 Output/Alarm Board

The channel 2 output/alarm board contains the cool channel output and the alarm relays circuitry.

The controller may be fitted with two alarms, and these alarms may be full scale high, full scale low, deviation, deviation low or deviation high. Also, the alarm relays may be energized or de-energized in alarm with normally open or normally closed contacts.

3.6 Remote Analog Setpoint Board

This board contains the remote setpoint (RLS,RLT) and the measured value out (MVO) circuitry.

The remote setpoint option provides the capability to change the Controller's setpoint with an external signal. The measured value out option provides an analog retransmission of the Controller's measured value.

3.7 Input Board

The input board accepts inputs from thermocouples, 3-wire resistance thermometers and voltage or current sources. The low level transducer signals are then amplified to a nominal maximum of 10VDC and applied to the A/D converter for conversion to digital form. The input board is attached to the microprocessor board. The zero and span adjustment potentiometers are also located on this board.

3.8 Isolated D.C. Sub-Boards A and B

These two boards contain the circuitry needed to provide the desired D.C. output. These two boards can produce both D.C. voltage or D.C. current outputs. The output is isolated.

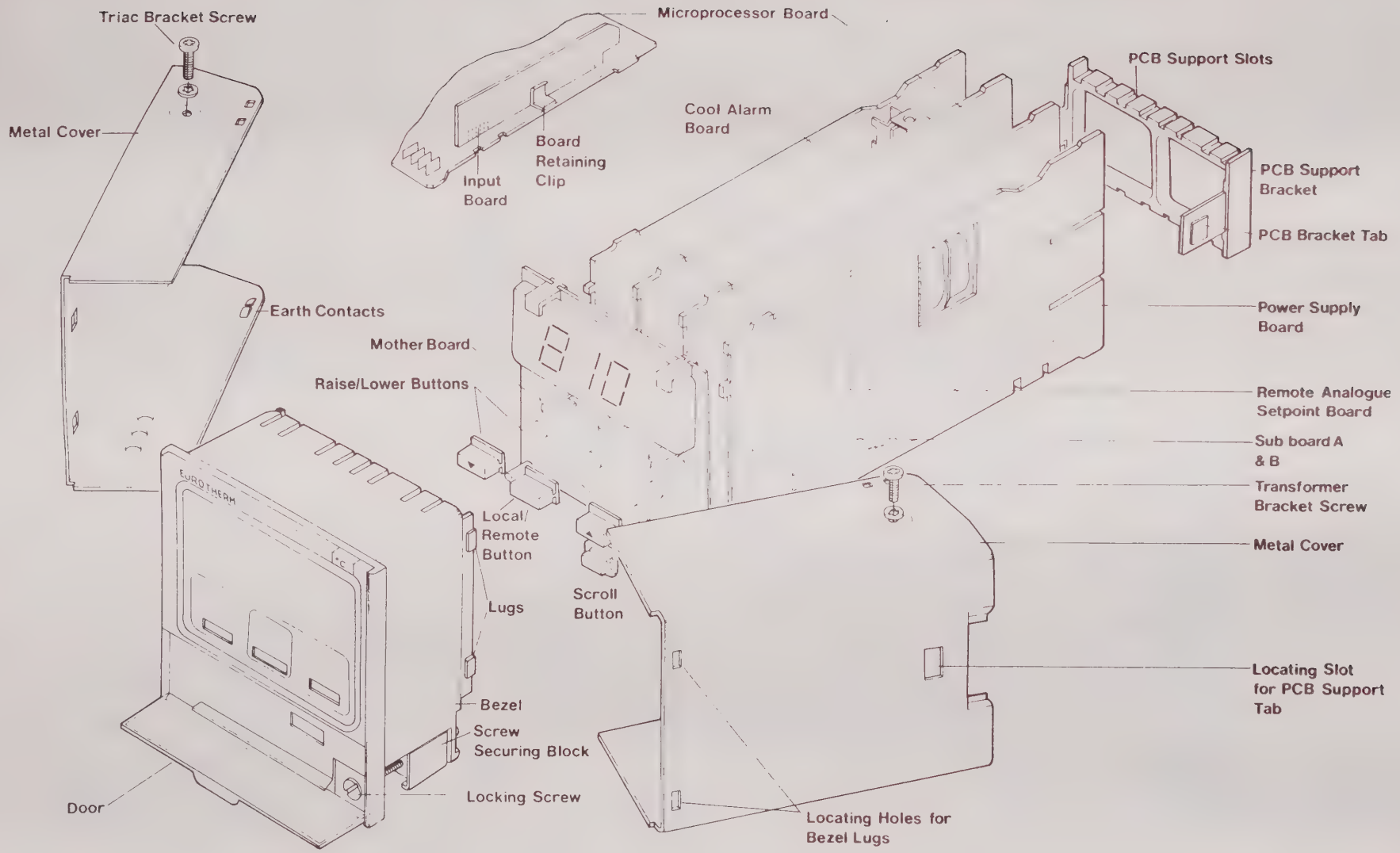


Figure 3-1: Mechanical Exploded View of 810 Controller

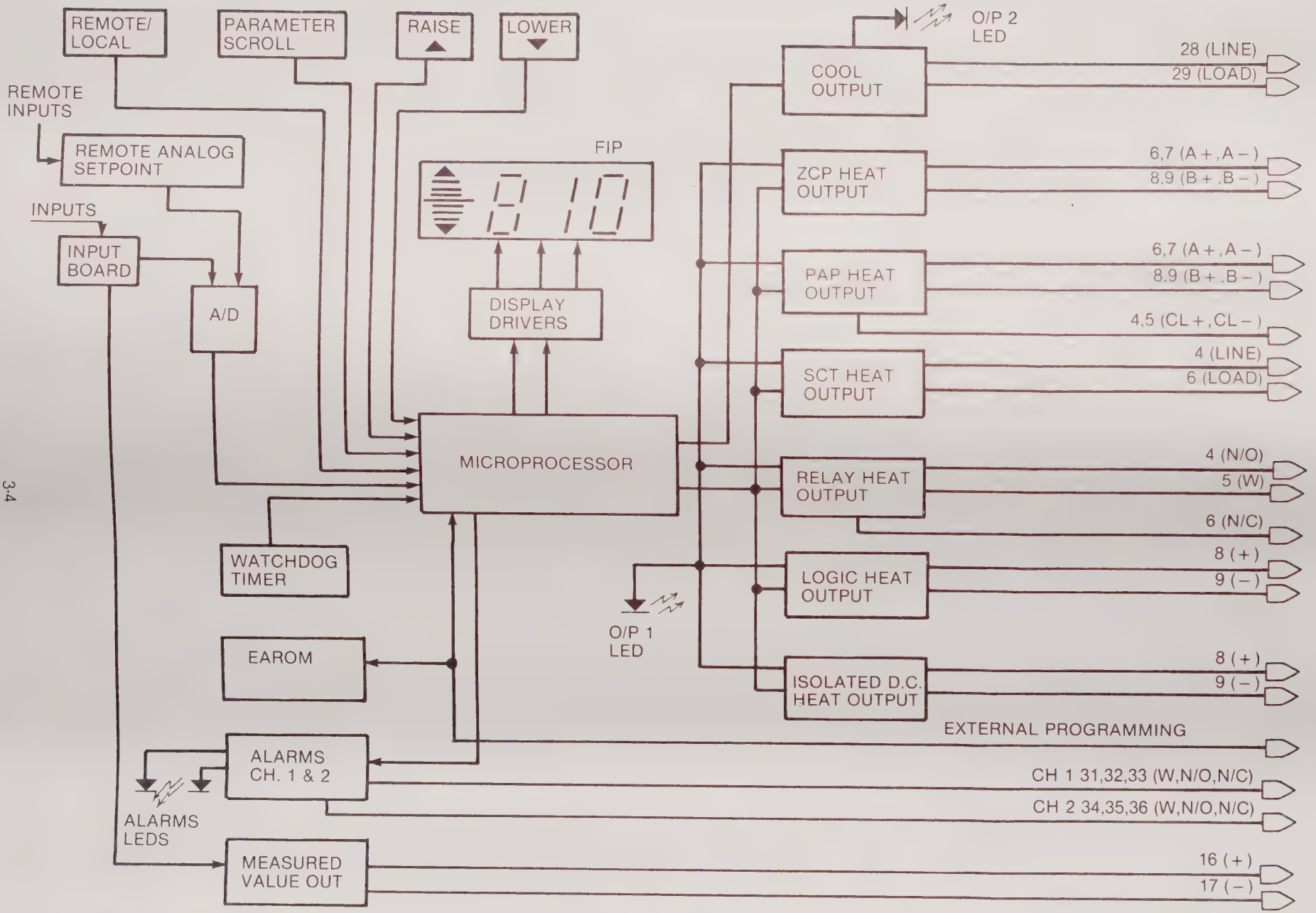


Figure 3-2: Functional Block Diagram of 810 Controller

REAR TERMINAL NUMBERS

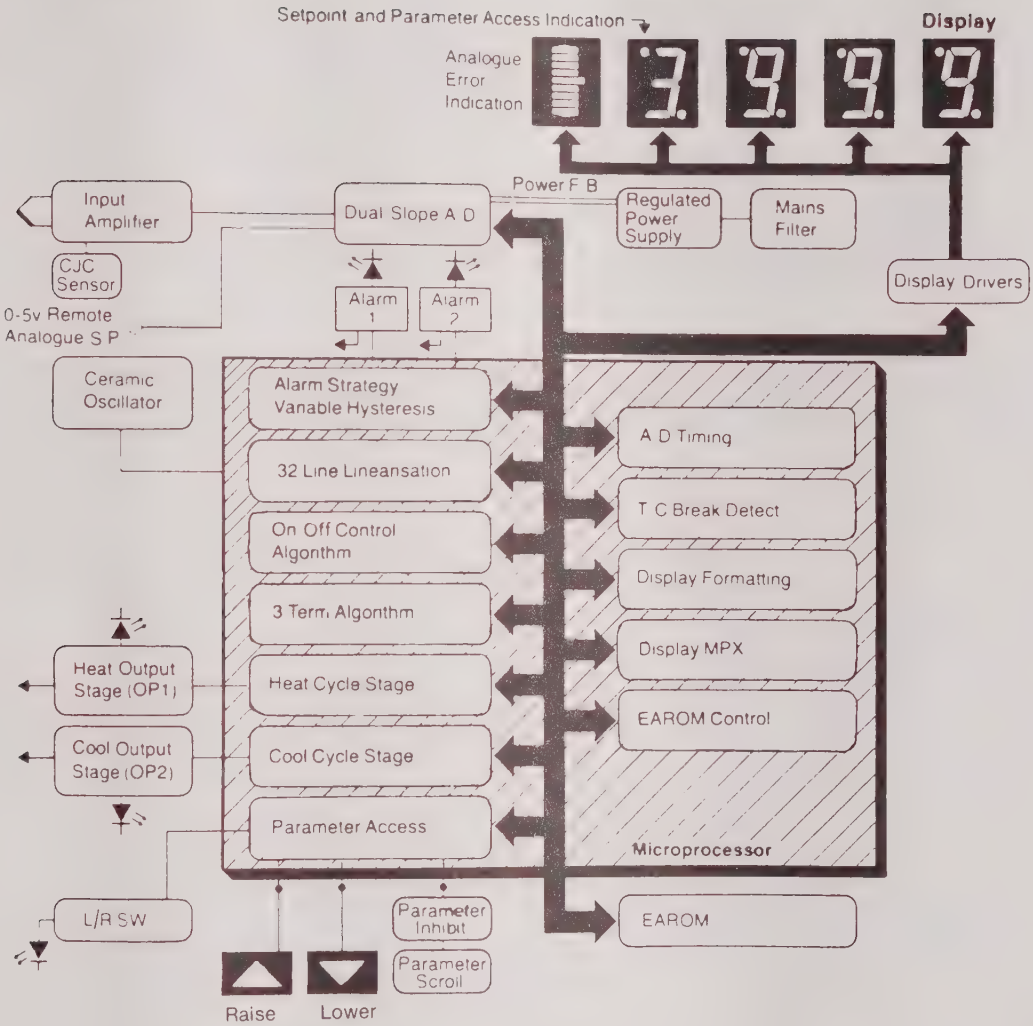


Figure 3-3: Microprocessor Block Diagram

SECTION IV

RECEIVING INSPECTION AND INSTALLATION INSTRUCTIONS

4.1 Unpacking and Unassembly Instructions

The Controller is shipped fully assembled and ready for installation. Exercise the normal precautions associated with unpacking electronic equipment. Visually check for any physical damage to the packing material. A detailed inspection should be made of the equipment surfaces that were adjacent to any damaged area.

4.2 Inspection Upon Receipt

Inspect the equipment for damage incurred during shipment as evidenced by bent or dented hardware, or cracked indicator lenses. Inventory the equipment against the packing list. If there is evidence of equipment damage, or if a part is missing, report the discrepancy.

4.3 Installation Instructions

The Temperature Controller is designed for fixed panel mounting in a 3.62 inch square (92mm) cutout. The Controller is retained by two (2) mounting clips. See figure 4.1 for instrument dimensions. A 30 position rear mounted screw terminal block allows interwiring for standard and optional instrument configurations.

a. Fixed Mounting

Fixed mounting installation procedures keyed to figure 4-2.

The instrument may be removed from its sleeve by opening the front panel access door and turning the locking screw in the bottom right-hand corner counter-clockwise with a screwdriver. The instrument will start to withdraw from its sleeve, and once the locking screw has been turned to its furthest extent, the Controller can be withdrawn by hand. Remove the top and bottom mounting clamps from the sleeve by turning the mounting screw counter-clockwise. Once the mounting screw has been withdrawn enough to clear the sleeve, gently ease the mounting clamp downwards inside the sleeve and remove. Insert the sleeve through the panel cut-out via the front of the panel. Fit the mounting clamps in the slots from the inside of the sleeve. From the rear of the mounting panel tighten the mounting screws with a screwdriver.

By hand ease the Controller into the sleeve to its furthest extent. DO NOT FORCE the instrument into the sleeve. The instrument will be protruding approximately ½" from the sleeve. With a screwdriver turn the locking screw in the bottom right-hand corner clockwise until tight. The Controller will be pulled completely into the sleeve, engaging the rear terminals, and be fully secure.

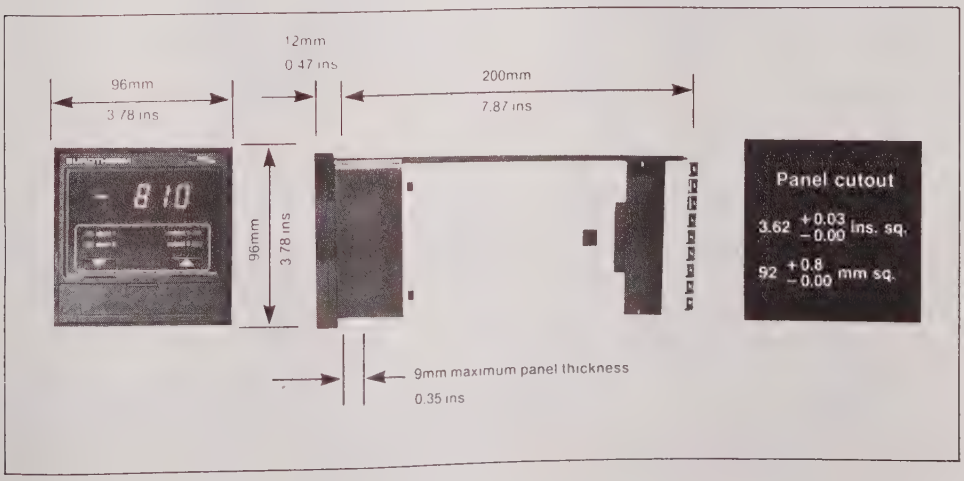


Figure 4-1: Instrument Mounting Dimensions

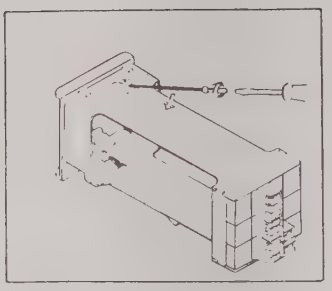


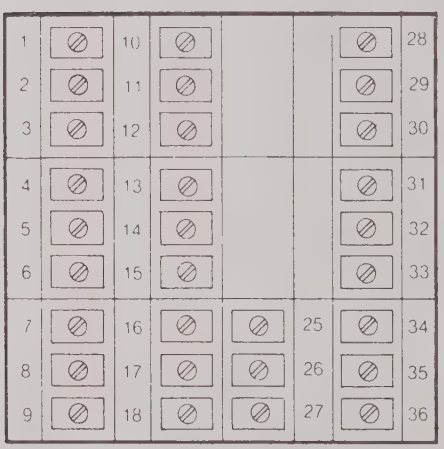
Figure 4-2: Instrument Mounting

4.4 Instrument Termination Procedures

a. General

Electrical connections to the Controller are made on the terminal block fitted with either 30 screw terminals or with 30 male faston terminals which connect with female receptacles. All connections are low current and usage of 20/AWG wire gauge size is adequate. The rear terminals can accommodate 16/AWG wire gauge size if required. A label mounted on the top of the mounting sleeve, figure 4-3, identifies all connections relevant to the instrument. When wiring sleeves, the terminal block on the sleeve is wired identically to the label on the instrument.

Note: Unlabeled Terminals should not be used as Tie-Points as they may be internally connected.



EUROTHERM

Model No: 810-073-065-101-617-24-112-405-00
Serial No: 810 OP MANUAL

2. 120 V
3. NEUTRAL
8. ISOLATED D.C. + 4-20mA
9. ISOLATED D.C. – (heat)
14. EXT. D.C. IN + 0-5V
15. EXT. D.C. IN – remote setpoint
18. EARTH
25. T/C +
27. T/C –
28. COOL TRIAC LINE.
29. COOL TRIAC LOAD.
31. ALARM RELAY COM.
32. ALARM RELAY N/O.
33. ALARM RELAY N/C.

Figure 4-3:
Instrument Terminal Block Connections and Connecting Information.

To facilitate making wire connections for the various instrument configurations, all pertinent data including connector functions, terminal block locations, wiring diagram figure references and remarks are referenced in Table 4-1.

b. Instrument Ground Connection

Ground connection procedures for fixed mounting instruments are provided at rear terminal 18. Refer to figure 4-3 during procedures.

Fixed Mounting

Attach ground wire to rear terminal 18.

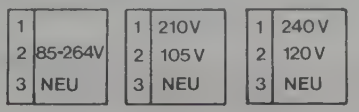
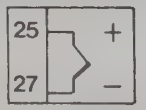
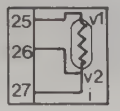
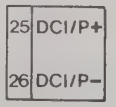
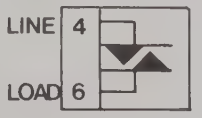
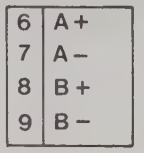
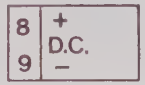
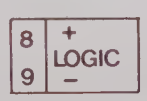
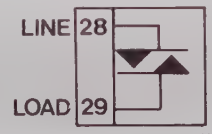
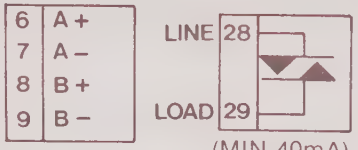
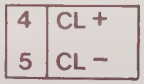
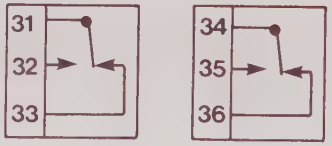
FUNCTION	TERMINAL CONNECTOR NO.	TERMINAL BLOCK LOCATION	REMARKS
Instrument Power	2 - 3, 1 - 3 or 2 - 3 (switch mode)		Connect the A.C. power leads between terminals 2 (105V/120VAC) and 3 (neutral) or between terminals 1 (210V/240VAC) and 3 (neutral) as required. Tolerances on the input transformer allow sufficient variation of supply voltages to accommodate standard instrument power. 105V/210V or 120V/240V 50 or 60 HZ. Use connector 18 as a ground. For the switch mode power supply, connect the A.C. power leads between terminals 2 (line) and 3 (neu.). The switch mode power supply can accommodate input supply voltages between 85 VAC and 264 VAC.
Controller Inputs a. Thermocouples	25 - 27		Thermocouple connections are made between terminals 25 (+) and 27 (–) on instruments with thermocouple sensing. Compensating lead wire of the correct type must be used between the load and the instrument, and it must be connected in the correct polarity.
b. Resistance Thermometer	25, 26, 27		Platinum resistance thermometer connections on instruments suitable for resistance thermometer sensing are made between terminals 25, 26 and 27. For 2 wire thermometers with short leads, connect the RTD leads between terminals 25 and 26 and jumper terminals 26 and 27.
c. D.C. Voltage or current	25 - 26		D.C. Voltage or Current Input Connections are made at terminals 25 (+) and 26 (–).
Controller Outputs a. Single Output Heat Only Slow Cycle Triac (SCT)	4 - 6 (see figure 4-4 Wiring Diagram)	(minimum current 40mA) 	Triac heating output connections are made between terminals 4 (Line) and 6 (Load). During the ON phase of the output cycle with the triac fired, the internal connection between terminals is made. This output is normally used to energize the coil of an external single or three phase conventional contactor or control relay. Triac rating is 1A/250V. An internal fast blow fuse (AGC1A/250V or equivalent) is used.
Single Phase SCR Pulses (ZCP/PAP)	6 - 7, 8 - 9 (see figure 4-5 Wiring Diagram)		Controllers with zero crossing (ZCP) or phase angle (PAP) pulse outputs have pulse pairs connected to terminals 6 (+), 7 (–), 8 (+) and 9 (–). Provision for current limit feedback is incorporated in all phase angle pulse (PAP) outputs. Pulse Outputs are fed to an external Eurotherm SCR unit employing SCR devices connected in inverse parallel. *NOTE:* When using phase angle switching with inductive loads, ensure that the load circuit is concurrently made with or before the supply to the instrument. The soft start feature of PAP will limit the inrush load current which may otherwise blow the semiconductor fuse. CONTROLLER AND SCR UNITS SHOULD BE REFERENCED TO THE SAME PHASE OF THE SUPPLY FOR PROPER PAP OPERATION.

Table 4-4: Temperature Controller Model 810 Terminal Block Connections

FUNCTION	TERMINAL CONNECTOR NO.	TERMINAL BLOCK LOCATION	REMARKS
D.C. Signals (0-5V, 4-20mA, etc.)	8 - 9 (see figure 4-6 Wiring Diagram)		For controllers providing DC analog signals, the outputs are connected to terminals 8 (+) and 9 (-). Outputs are isolated and suitable for use with external Eurotherm drivers or other process controllers and power packs
Relay	4, 5, 6 (see figure 4-8 Wiring Diagram)		Relay heating output connections are made between terminals 4 (NO), 5 (NC) and 6 (Wiper). Contact is rated for 10^5 operations. Slow cycle or ON-OFF control is available. Output is suitable for low power loads only, or for use with Eurotherm contactors.
Logic	8 - 9 (see figure 4-9 Wiring Diagram)		Logic output connections are provided at terminals 8 (+) and 9 (–). There are two types of logic outputs. One is an isolated logic output rated at 7V at 11mA; the other is an unisolated logic output rated at 13.5V at 15mA. These are the minimum specifications for a logic output. These outputs are suitable for use with Eurotherm solid state contactors. The unisolated logic output should only be used to drive a fully isolated input.
b. Dual Outputs (Heat/Cool) (1) Heat Channel (SCT)	4 - 6 (see figure 4-7 Wiring Diagram)	(min 40ma) 	Triac heating output connections are made to terminals 4 (Line) and 6 (Load), enabling heating power to be fed to the load when triac is fired. The heat channel output is normally used to energize the coil of a conventional or control relay. Triac rating is 1A, 250V. An internal fast blow fuse (AGC 1A/250V or equivalent) is used.
(2) Cool Channel (SCT)	28 - 29 (see figure 4-7 Wiring Diagram)	(min 40ma) 	Triac cooling output connections are made on terminals 28 (Line) and 29 (Load), enabling cooling power to be fed to the load when the triac is fired. The cooling channel output is normally used to energize the coil of a fan motor contactor for air cooling, or the coil of a solenoid valve for water cooling. Triac rating is 1A, 250V. An external fast blow fuse (AGC 1A/250V or equivalent) is recommended.
(a) Air Cooling (TL)	28 - 29 (see figure 4-7 Wiring Diagram)	Terminal connections same as (2) above	Order instrument with a slow cycle triac and linear cooling characteristics (TL).

FUNCTION	TERMINAL CONNECTOR NO.	TERMINAL BLOCK LOCATION	REMARKS
(b) Water Cooling (TNL)	28 - 29 (see figure 4-7 Wiring Diagram)	Terminal connections same as (2) above	Order instrument with a slow cycle triac and non-linear cooling characteristics (TNL).
(c) Air Cooling (TOO)	28 - 29 (see figure 4-7 Wiring Diagram)	Terminal connections same as (2) above	ON-OFF triac cooling. Order instrument with triac ON/OFF cooling characteristics (TOO).
(3) Heat/Cool (ZCP/SCT) (PAP/SCT)	6 - 7, 8 - 9 (see figure 4-10 Wiring Diagram)		The heat channel output is a two pulse pair either zero crossing pulses or phase angle pulses connected to terminals 6 (+), 7 (–), 8 (+) and 9 (–). These pulse pairs are in turn connected to an external Eurotherm SCR unit with SCR devices connected in inverse parallel. Since standard SCR units accept 2 pulse pairs, the SCR unit used with a heat/cool controller must be fitted with an internal pulse transformer. All Model 932 and 931 SCR units are automatically fitted with this transformer. Model 831 SCR units require only one (1) set of pulses. Models 031 and 032 require both sets of pulses. The Controller and the SCR unit should be referenced to the same phase of the supply. Triac cooling output connections, including air and water cooling characteristics, are identical to the cool channel SCT output controllers previously described.
Optional Functions a. Current Limit (CL)	4 - 5 (see figure 4-10 Wiring Diagram)		On controllers with phase angle pulse outputs to Eurotherm SCR units, a current limit facility is available as a standard option. A current limit feedback signal is fed from the SCR unit to controller terminals 4 (+) and 5 (–). This option is available ONLY on heat outputs.
b. Low Limit Alarm (LL)	31, 32, 33, 34, 35 36 (see figure 4-11 Wiring Diagram)		Alarm output relay is deenergized with power OFF and with power ON and temperature in the "ALARM" condition (below alarm setpoint). The alarm relay is energized with power ON and temperature in the "SAFE" condition (above alarm setpoint). This is the standard configuration. It is possible to configure the alarm output relay such that it is energized with power ON and temperature in the "ALARM" condition. Normally open (NO) and normally closed (NC) contacts are available. NO and NC refer to the contact state when the alarm relay is deenergized. Relay contacts are rated at 1A, 240VAC. Wire connections are made between terminals 31 (Wiper), 32 (NO), and 33 (NC) for alarm relay 1. Wire connections for alarm relay 2 are made between terminals 34 (Wiper), 35 (NO), and 36 (NC).

FUNCTION	TERMINAL CONNECTOR NO.	TERMINAL BLOCK LOCATION	REMARKS
c. High Limit Alarm (HL)	31, 32, 33, 34, 35, 36 (see figure 4-11 Wiring Diagram)	Terminal connections same as b. above	Alarm output relay is deenergized with power OFF, and with power ON and temperature in the "ALARM" condition (above alarm setpoint). Alarm relay is energized with power ON and temperature in the "SAFE" condition (below alarm setpoint). This is the standard configuration. It is possible to configure the alarm output relay such that it is energized with power ON and temperature in the "ALARM" condition. Normally open (NO) and normally closed (NC) contact outputs are available. NO and NC refer to the contact state when the alarm relay is deenergized. Relay contacts are rated at 1A, 240VAC Wire connections are made as stated for the low limit alarm option
d. Deviation Limit Alarm (DL)	31, 32, 33, 34, 35, 36 (see figure 4-11 Wiring Diagram)	Terminal connections same as b. above	Alarm output relay is deenergized with power OFF, and with power ON and temperature in the "ALARM" condition (out of band about setpoint) Alarm relay is energized with power ON and temperature in the "SAFE" condition (within band). This is the standard configuration. It is possible to configure the alarm output relay such that it is energized with power ON and temperature in the "ALARM" condition. Normally open (NO) and normally closed (NC) contact outputs are available. NO and NC refer to the contact state when the alarm relay is deenergized. Relay contacts are rated at 1A, 240VAC. Wire connections are made as stated for the low limit alarm option.
e. Process Alarm (FSH)	31, 32, 33, 34, 35, 36 (see figure 4-11 Wiring Diagram)	Terminal connections same as b. above	Alarm output relay is deenergized with power OFF, and with power ON and temperature in the "ALARM" condition (above alarm setpoint). Alarm relay is energized with power ON and temperature in the "SAFE" condition (below alarm setpoint). This is the standard configuration. It is possible to configure the alarm output relay such that it is energized with power ON and temperature in the "ALARM" condition. Normally open (NO) and normally closed (NC) contact outputs are available. NO and NC refer to the contact state when the alarm relay is deenergized. Relay contacts are rated at 1A, 240VAC. Wire connections are made as stated for the low limit alarm option.
f. Process Alarm (FSL)	31, 32, 33, 34, 35, 36 (see figure 4-11 Wiring Diagram)	Terminal connections same as b. above	Output relay is deenergized with power OFF, and with power ON and temperature in the "ALARM" condition (below alarm setpoint). Alarm relay is energized with power ON and temperature in the "SAFE" condition (above alarm setpoint). This is the standard configuration. It is possible to configure the alarm output relay such that it is energized with power ON and temperature in the "ALARM" condition. Normally open (NO) and normally closed (NC) contact outputs are available. NO and NC refer to the contact state when the alarm relay is deenergized. Relay contacts are rated at 1A, 240VAC. Wire connections are made as stated for the low limit alarm option.
g. Remote/Local Setpoint (RLS,RLT)	14 - 15	14 + RLS 15 −	Remote setpoint connections are provided at rear terminals 14 (+) and 15 (−). The front panel RLS LED determines from which setpoint the controller is operating.
h. Measured Value Out (MVO)	16 - 17	16 + MVO 17 −	An unlinearized 0-10V (10mA MAX) analog retransmission of the measured value is provided on rear terminals 16 (+) and 17 (−). This output is NOT isolated from the input circuitry; therefore all connections to these terminals should be fully isolated from any source or supply.

Caution: Interconnections made to instruments other than as shown, can result in improper operation or equipment damage.

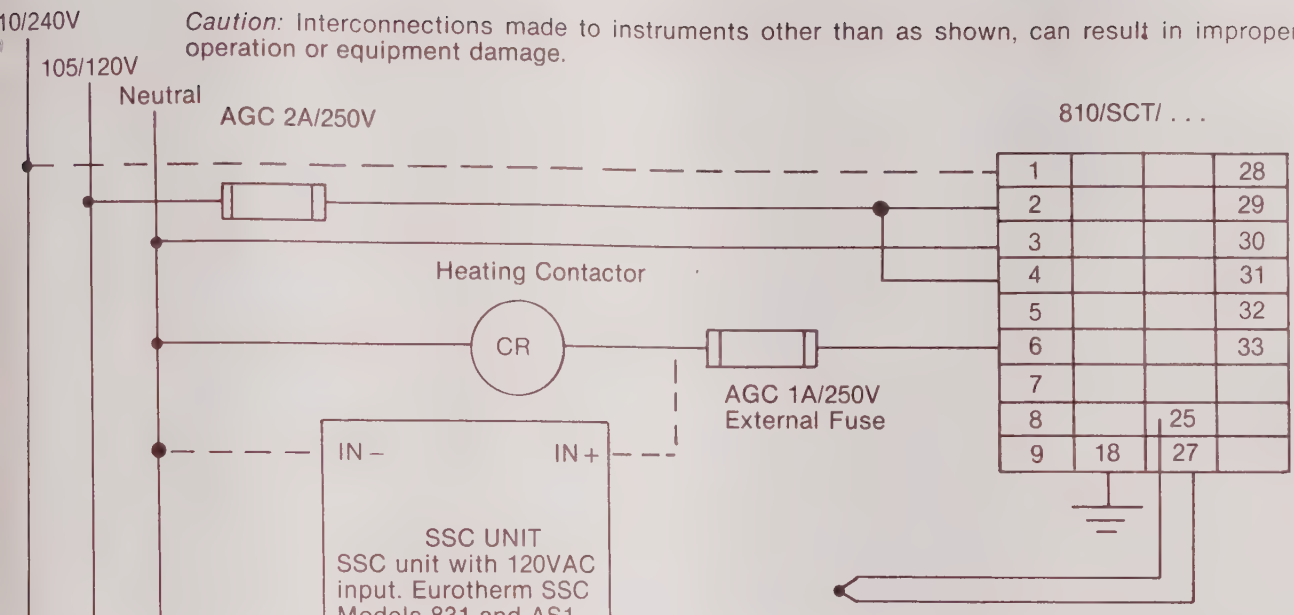


Figure 4-4: Single Output—SCT Triac Output

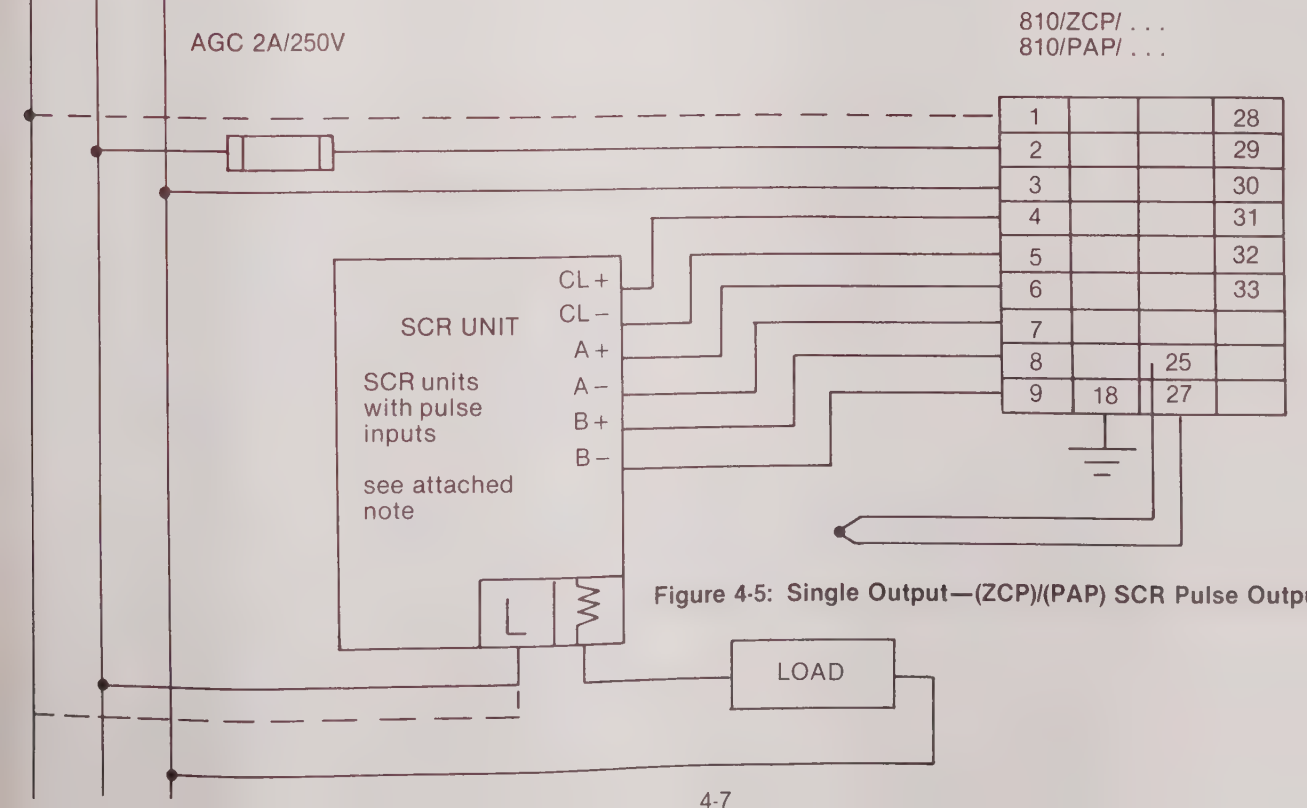


Figure 4-5: Single Output—(ZCP)/(PAP) SCR Pulse Outputs

Caution: Interconnections made to instruments other than as shown, can result in improper operation or equipment damage.

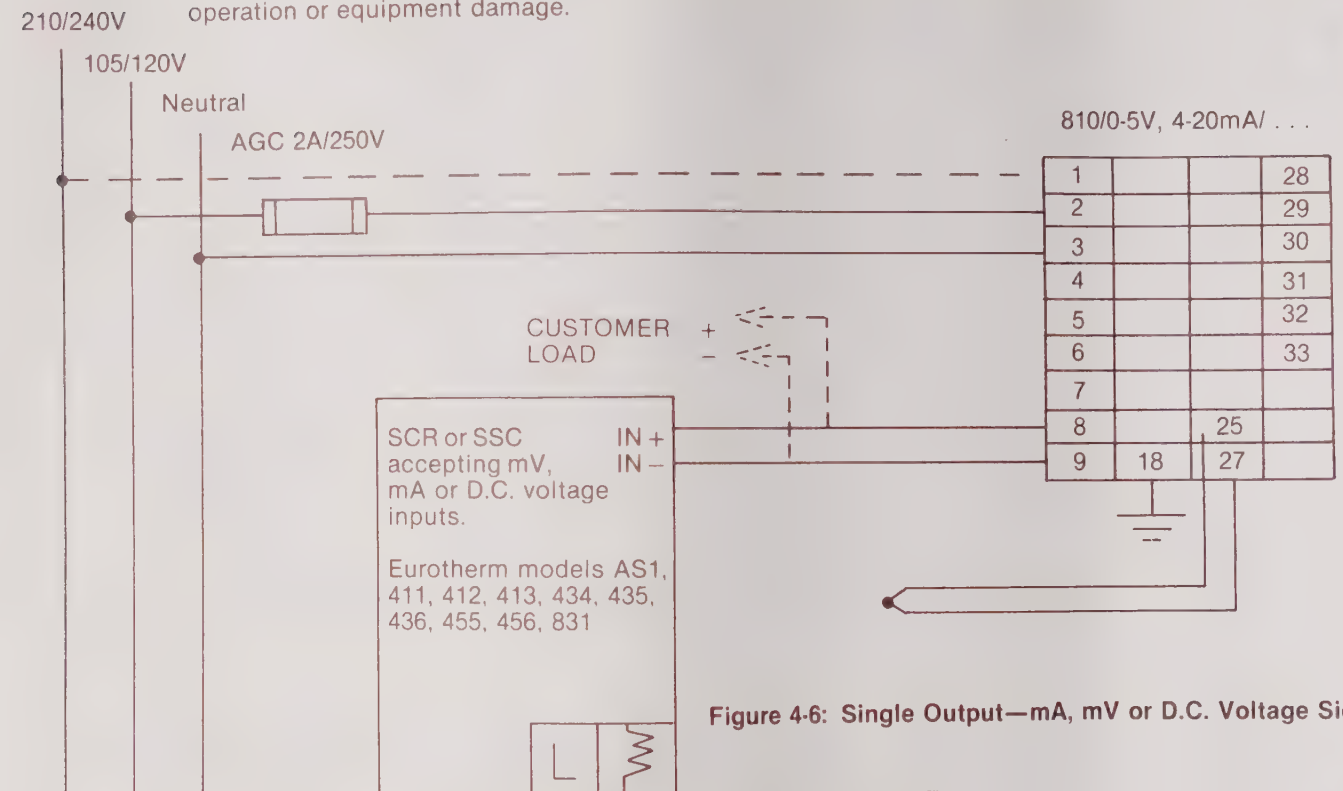


Figure 4-6: Single Output—mA, mV or D.C. Voltage Signals

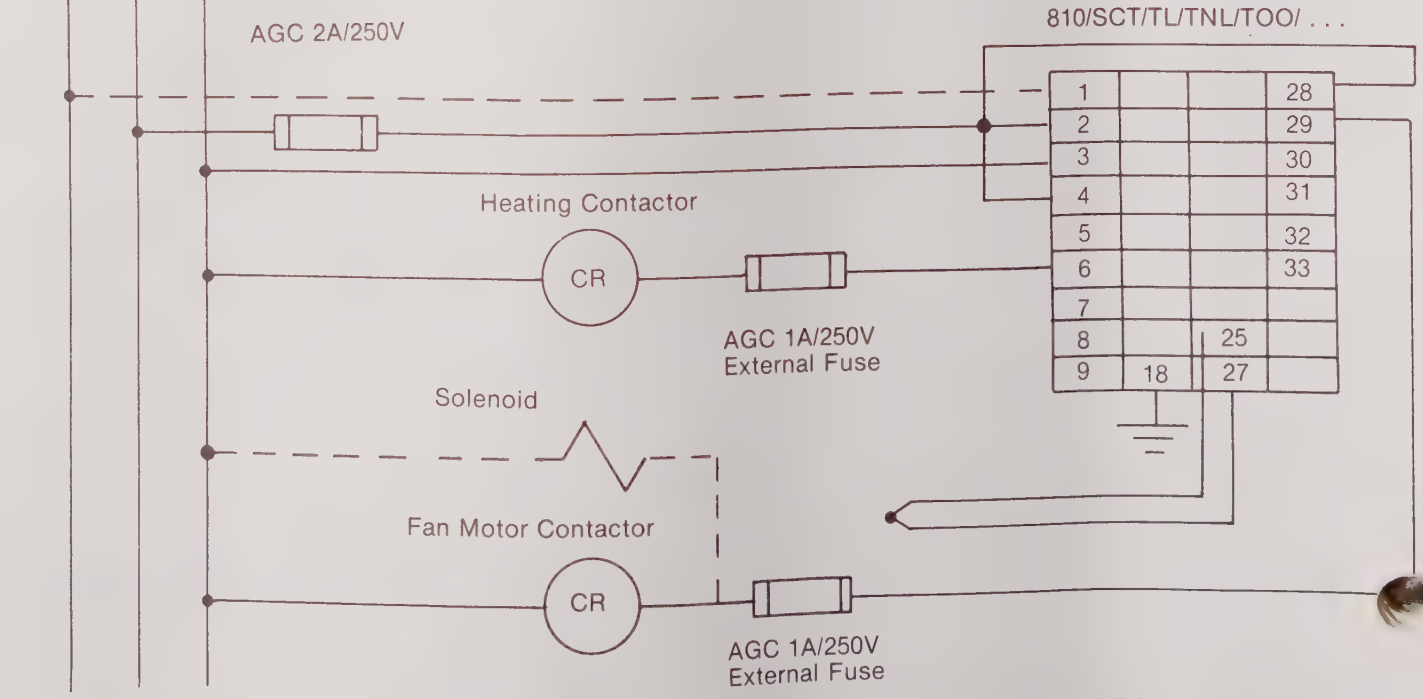


Figure 4-7: Dual Output—SCT/SCT Dual Triac Outputs

Caution: Interconnections made to instruments other than as shown, can result in improper operation or equipment damage.

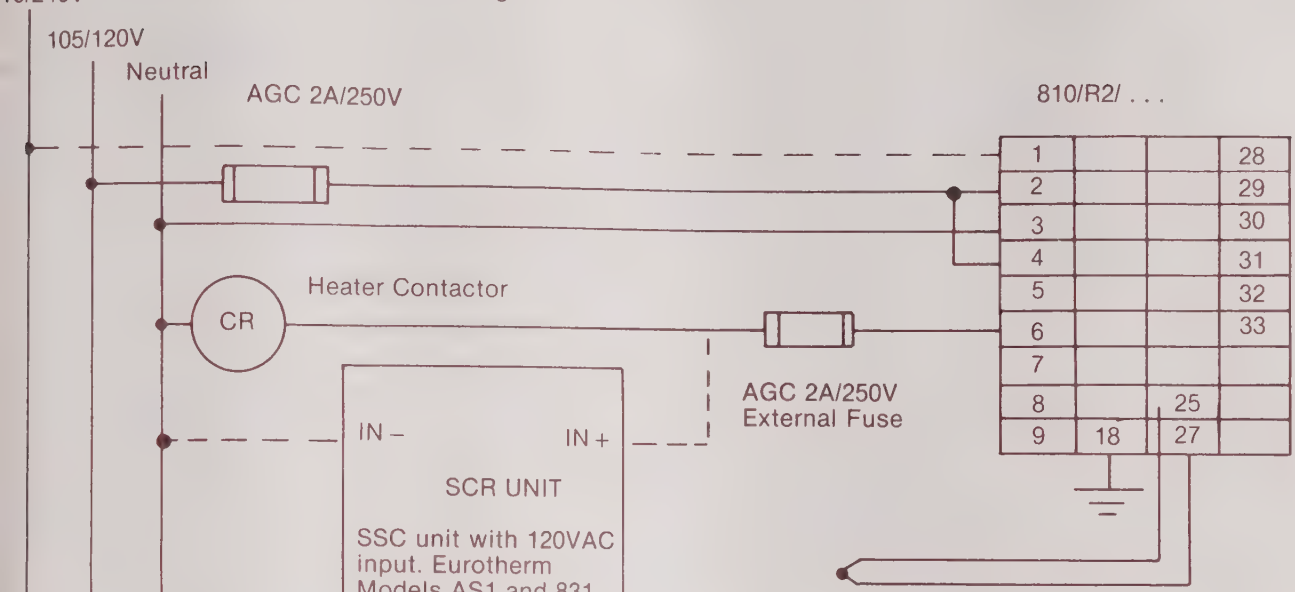


Figure 4-8: Single Output—R2 Relay Output

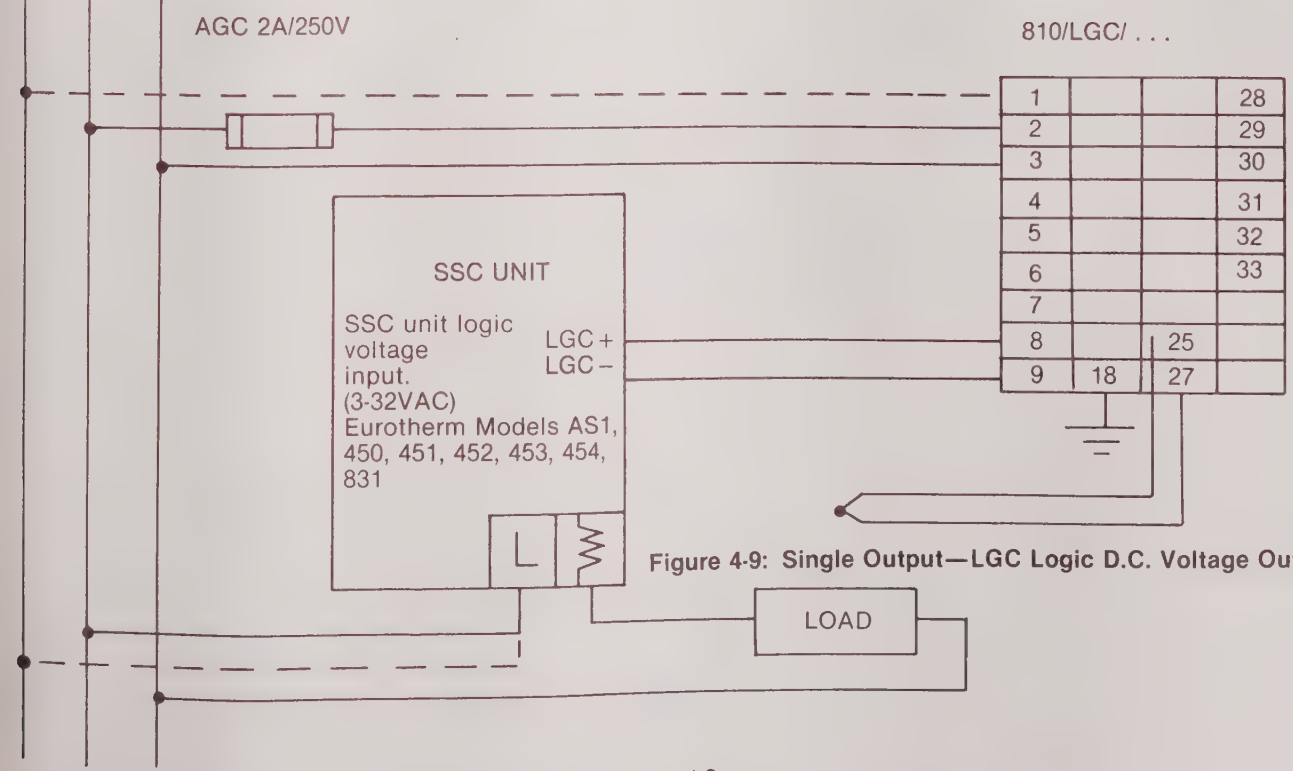


Figure 4-9: Single Output—LGC Logic D.C. Voltage Output

Caution: Interconnections made to instruments other than as shown, can result in improper operation or equipment damage.

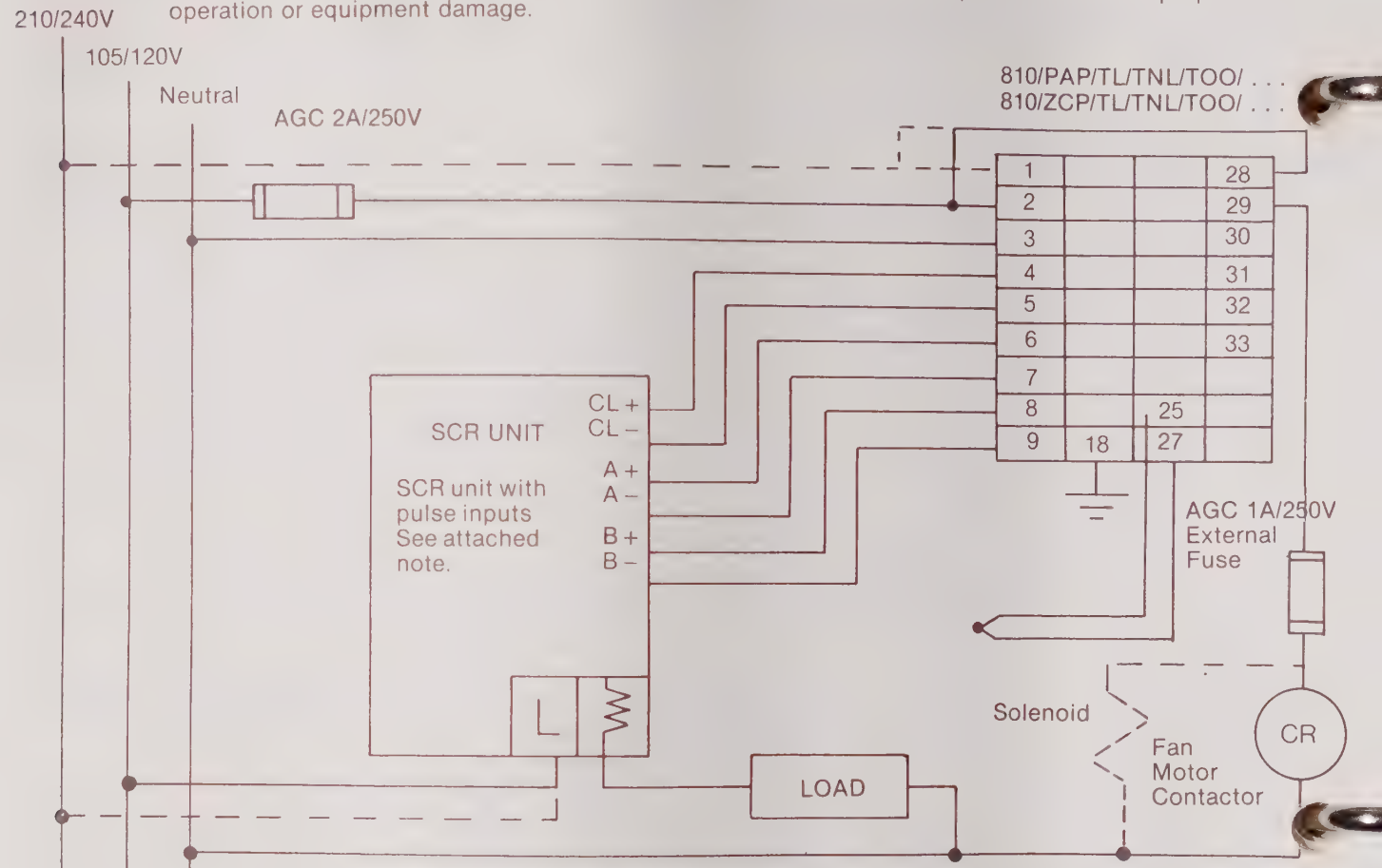


Figure 4-10: Dual Outputs—(ZCP)/(SCT) (PAP)/(SCT) SCR Pulse Heat/Triac Cool

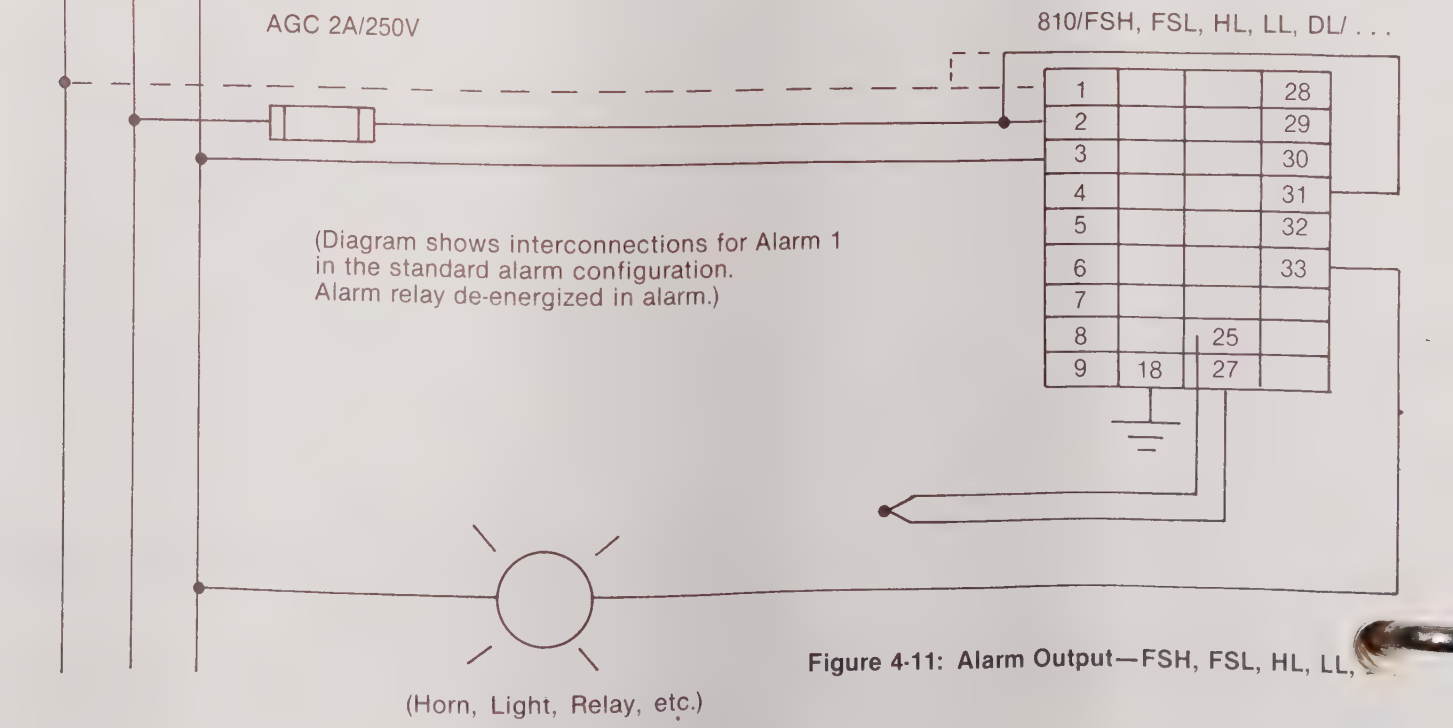


Figure 4-11: Alarm Output—FSH, FSL, HL, LL,

Note on Figure 4-5 Wiring Diagram

Eurotherm SCR Assemblies Model 031 and 032 require a 4-wire interface, thus both sets of pulses must be connected.

Eurotherm SCR Assemblies Model 831, 931, 932, 961, 962 require only a 2-wire interface, thus only 1 set of pulses (6 & 7 or 8 & 9) need to be connected.

For proper PAP operation, both the SCR assembly and the Controller MUST be referenced to the same phase of the power source.

The CL+ and CL– terminal connections (Current Limit Feedback) are only applicable to PAP output models.

Check with the SCR or SSC Installation Information Manual for proper SCR or SSC terminal designation.

Note on Figure 4-10 Wiring Diagram

Eurotherm SCR Assemblies Model 031 and 032 require a 4-wire interface, thus both sets of pulses must be connected.

Eurotherm SCR Assemblies Model 831, 931, 932, 961, 962 require only a 2-wire interface, thus only 1 set of pulses (6 & 7 or 8 & 9) need to be connected.

For proper PAP operation, both the SCR assembly and the Controller MUST be referenced to the same phase of the power source.

The CL+ and CL– terminal connections (Current Limit Feedback) are only applicable to PAP output models.

Check the SCR Installation Information Manual for proper SCR terminal designation.

SECTION V

OPERATING INSTRUCTIONS

5.1 General

This section contains operating instructions for the Eurotherm Model 810 Temperature Controller. Instructions consist of control and indicator descriptions and detailed operating procedures.

5.2 Controls and Indicators

Operator controls and indicators are listed and described in Table 5-1. Control/indicator locations, which numerically correspond with Table 5-1, are illustrated in figure 5-1.

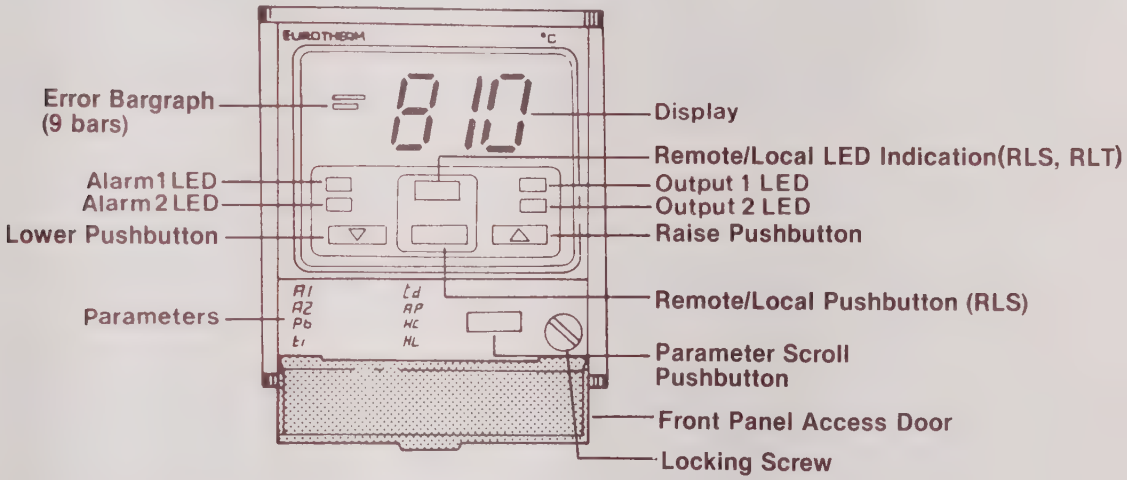


Figure 5-1: Controls and Indicators for Model 810 Temperature Controller

1. Channel 1 Output Indicator Output 1 LED (YELLOW)
2. Channel 2 Output Indicator Output 2 LED (YELLOW)
3. Display
4. RAISE Pushbutton
5. LOWER Pushbutton
6. Error Bargraph
7. Alarm 1 LED Indication (RED)
8. Alarm 2 LED Indication (RED)
9. Remote/Local Pushbutton (RLS)
10. Remote/Local LED Indication (RLS, RLT)
11. PARAMETER SCROLL Pushbutton
12. Front Panel Access Door
13. List of Control Parameters
14. Locking (Jacking) Screw

Table 5-1: **Model 810 Temperature Controller Controls and Indicators**

ITEM NO.	CONTROL/INDICATOR	FUNCTION
1.	Channel 1 Output Indicator, Output 1 LED (YELLOW) (HEAT)	Indicates power to load and is yellow for all outputs. For DC outputs, the degree of brightness intensifies as the voltage (or current) increases from minimum to maximum. In the zero crossing fired (fast cycle fired) SCR pulse output, the LED blinks brightly at each zero cross firing. In the phase angle fired SCR pulse output, brightness intensifies as firing angle increases. In the slow cycle fired triac output, the LED will display full brightness when the triac is fired and passing current. In all cases this LED indicator is HEAT to load.
2.	Channel 2 Output Indicator, Output 2 LED (YELLOW) (COOL)	Indicator is used only in heat/cool instruments for monitoring the state of the cool channel. Illumination of Output 2 LED occurs under the same conditions as that described for LED 1 (Item 1) except LED 2 applies to the cool channel output.
3.	Display	Displays all process variables including setpoint, measured value, proportional band, etc.
4.	RAISE Pushbutton	When depressed allows the value of the parameter being viewed to be raised.
5.	LOWER Pushbutton	When depressed allows the value of the parameter being viewed to be lowered.
6.	Error Bargraph	Gives an analog indication of proximity to setpoint.
7.	Alarm 1 LED Indication (RED)	Provides LED indication of ALARM 1 condition. The LED is illuminated in the alarm state.
8.	Alarm 2 LED Indication (RED)	Provides LED indication of ALARM 2 condition. The LED is illuminated in the alarm state.
9.	Remote/Local Pushbutton (RLS)	Provided on instruments fitted with the remote/local option. Depression of this pushbutton will cause the controller to operate from a remote setpoint.
10.	Remote/Local LED Indication (RLS, RLT)	Provided on instruments fitted with the remote/local option. When the controller is operating from a remote setpoint, this LED will be illuminated; otherwise it is off.
11.	PARAMETER SCROLL Pushbutton	Depression of this pushbutton allows the control parameters associated with the Controller to be viewed.
12.	Front Panel Access Door	Provides access to the PARAMETER SCROLL pushbutton and the locking (jacking) screw.
13.	List of Control Parameters	A list of all the control parameters associated with the Controller and their display mnemonic symbols (example: Hc—Heat Cycle Time).
14.	Locking (Jacking) Screw	Allows the Controller to be secured into its sleeve.

5.3 Temperature Controller Operation

Detailed instructions for operating the Controller and for the associated Controller functions are provided in the following paragraphs.

a. Indications

Measured value is displayed during normal operations. A flashing dot in the upper top left-hand corner of the display will indicate that a parameter other than measured value is being displayed. A timed interlock holds the parameter value, unless a change is made, for four to five seconds.

Behind the front panel access door on the instrument fascia and on the front panel access door itself, there is listed a series of control parameters pertinent to the Controller. Each parameter is listed in its mnemonic form. These mnemonics usually appear in the two right-hand display positions of the display. In some controllers, the mnemonics may appear in the two left-hand display positions.

Up to five (5) LEDS may be installed on the Controller's front fascia to provide a visual indication of alarms, outputs, and remote/local status.

b. Basic Operation

Four control pushbuttons on the front of the Controller cover all operation facilities of the instrument.

The setpoint is adjusted by depression of either the RAISE▲ or LOWER▼ pushbutton. Prolonged depression of either pushbutton gives an accelerating display, and single least significant digit changes are accomplished by individual button pushes.

Various control parameters—such as proportional band, integral and derivative time constants, approach, heat and cool cycle times, heat and cool maximum power, relative cool, and alarm setpoints—are selected by depression of the PARAMETER SCROLL pushbutton located behind the front panel access door. Continuous individual depression of the PARAMETER SCROLL pushbutton selects parameters in turn. To change a parameter value after selection by the PARAMETER SCROLL pushbutton, wait approximately two (2) seconds. The parameter mnemonic will be replaced by the present parameter value.* Depress the respective RAISE▲ or LOWER▼ pushbutton to make a parameter value change. Until the PARAMETER SCROLL pushbutton is released, the first letter of the parameter mnemonic will not be displayed. Also, if no action is taken by the operator within eight (8) seconds of the last action, the display will automatically revert to indicating measured value.

An optional REMOTE/LOCAL pushbutton may be installed on the instrument's front fascia.

A PARAMETER SCROLL DISABLE switch is provided on all Controllers. This is an on-off slide switch located at the rear of the microprocessor board. If this switch is enabled, it will not be possible to view or change any parameters associated with the controller except for setpoint. Controllers are shipped from the factory with the PARAMETER SCROLL DISABLE SWITCH disabled. See figure 5-2.

*Note: On controllers fitted with the self-tuning option (ST), the parameter mnemonic is NOT replaced by the present parameter value after two (2) seconds. Instead, the display will automatically revert to displaying measured value. To view the present parameter value, depress the PARAMETER SCROLL pushbutton until the desired parameter mnemonic is displayed; then depress either the RAISE or LOWER pushbutton to view the present parameter value. Continued depression of either the RAISE or LOWER pushbutton will then cause a parameter value change.

c. Parameters

Following is a detailed discussion of all parameters associated with the Model 810 Microprocessor Based Controller. All of these parameters may be viewed by continued individual depression of the PARAMETER SCROLL pushbutton. To change the value of any of these parameters after selection by the PARAMETER SCROLL pushbutton, wait approximately two (2) seconds—except on controllers fitted with the self-tuning option. The parameter mnemonic will be replaced by the present parameter value. Depress the respective RAISE or LOWER pushbutton until the required parameter value is reached. Some parameters discussed may not be viewed because the Controller does not require their function. Shown beside each parameter is its associated mnemonic display.

A1—ALARM 1

ALARM 1 temperature setpoint in instrument degrees. The value of A1 determines at what temperature alarm relay 1 will go into its alarm state. ALARM 1 may be a full scale high, a full scale low, a low, a high or a deviation alarm.

A2—ALARM 2

ALARM 2 temperature setpoint in instrument degrees. The value of A2 determines at what temperature alarm relay 2 will go into its alarm state. ALARM 2 may be a full scale high, a full scale low, a low, a high or a deviation alarm.

AL—ALARM

Alarm temperature setpoint in instrument degrees. For instruments with special options only one (1) alarm is available, and this is the alarm setpoint. The value of AL determines at what temperature the alarm relay will go into its alarm state. The ALARM may be a full scale low, a full scale high, a low, a high, or a deviation alarm.

Limit Alarm Note

When the controller is fitted with a high, a low, or a deviation alarm, the alarm setpoint can be adjusted between zero and a top limit, where the top limit is 20% of the instrument span. The limits for a full scale high or a full scale low alarm are zero and the span of the instrument.

tn or tu—SELF-TUNE ENABLE/DISABLE

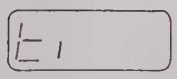
This is the Self-Tune Enable/Disable software switch. To enable Self-Tuning, depress the PARAMETER SCROLL pushbutton until the tn or tu mnemonic is displayed. To then enable Self-Tuning, depress the RAISE pushbutton. When the Self-Tuning Algorithm is enabled, the Controller will determine first if it is applicable to self tune based on certain restrictions. If Self-Tuning is allowed, the Controller will tune the load based on a 1/4 cycle period of oscillation. See section 5-5, Self-Tune option, for more information.

To disable Self-Tuning, depress the PARAMETER SCROLL pushbutton until the tn or tu mnemonic is displayed. To disable the Self-Tuning algorithm, depress the LOWER pushbutton. Self-Tuning will be disabled, and the Controller will operate with the control parameters it had prior to Self-Tuning being disabled.

Pb—PROPORTIONAL BANDWIDTH, ON/OFF HYSTERESIS % OF INSTRUMENT SPAN

This is the Proportional Bandwidth control parameter. To obtain optimum control, the proportional bandwidth must be determined using the procedures discussed under section 5-4. For instruments with ON/OFF control, the value of Pb sets the ON/OFF hysteresis in % of instrument span. The proportional bandwidth values are adjustable in 15 steps from 0.5 to 100%.

ti—INTEGRAL TIME CONSTANT IN SECONDS (RESET)



This is the Integral Time Constant control parameter in seconds. To obtain optimum control, the Integral Time Constant must be determined using the procedure discussed under section 5-4. The Integral Time Constant parameter is adjustable in 14 steps from integral OFF to 1800 seconds.

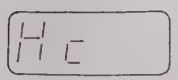
td—DERIVATIVE TIME CONSTANT IN SECONDS (RATE)

This is the Derivative Time Constant control parameter in seconds. To obtain optimum control, the Derivative Time Constant must be determined using the procedure discussed under section 5-4. The Derivative Time Constant parameter is adjustable in 13 steps from derivative OFF to 600 seconds.

AP—APPROACH CONTROL

The Approach Control parameter adjusts the start-up characteristics of the system under control by releasing the derivative action at some variable point below setpoint. The Approach Control parameter is expressed as the number of proportional bands below the setpoint, and its major function is to reduce temperature overshoot on start-up or large setpoint changes. The Approach Control parameter is adjustable in 9 steps from 0.25 to 3. See section 5.4, Control Stability, for more information on how to set the Approach Control parameter.

Hc—HEAT OUTPUT CYCLE TIME IN SECONDS



The Heat Output Cycle Time parameter adjusts the heat output cycle time. The Heat Output Cycle Time should ideally be set to the lowest time possible for the particular application.

For logic and ZCP heat outputs, the Heat Output Cycle Time is normally set to 0.3 seconds. For D.C. and PAP heat outputs, the heat output cycle time is fixed at 0.3 seconds and the Heat Output Cycle Time parameter is inoperative. For relay and SCT heat outputs, the Heat Output Cycle Time is normally set to 20 seconds. Heat Output Cycle Times less than 20 seconds for a relay output can cause increased contact wear and premature relay failure. The Heat Output Cycle Time parameter is inoperative on instruments with ON/OFF control. The Heat Output Cycle Time is adjustable in 7 steps from 0.3 to 80 seconds.

HL—HEAT MAXIMUM POWER

This is the Heat Maximum Power control parameter. This parameter limits the maximum heat power that may be applied to the load. This parameter may be used in place of a variac in many applications and can also be used to approximately control the rate of rise of temperature during system start-up. Two important uses for this parameter are in limiting electrical current supplied to loads which display a large negative temperature coefficient of resistance or in limiting power to over-powered heaters. The Heat Maximum Power parameter is adjustable from 0 to 100% in increments of 1%, and this parameter has a linear relationship between 0 and 100%. The Heat Maximum Power Parameter is normally set to 100%.

Cc—COOL OUTPUT CYCLE TIME IN SECONDS

This is the Cool Output Cycle Time in seconds. The Cool Output Cycle Time should ideally be set to the lowest time possible for the particular application. On non-linear cool outputs, TNL, the Cool Output Cycle time is set to 10 seconds, and the Cc parameter is inoperative. The Cool Output Cycle Time is adjustable in 7 steps from 0.3 to 80 seconds.

Cr—RELATIVE COOL GAIN

This is the Relative Cool Gain control parameter. The Relative Cool Gain is relative to the primary or heat output channel. The Relative Cool Gain is adjustable in 9 steps from 0.25 to 3.0. See section 5-4 for a procedure on how to determine the Relative Cool Gain parameter setting.

CL—COOL MAXIMUM POWER

This is the Cool Maximum Power control parameter. This parameter limits the maximum cool power that may be applied to the load. The Cool Maximum Power is adjustable from 0 to 100% in increments of 1%. The Cool Maximum Power is normally set to 100%.

END

Once all control parameters have been scrolled, the word END is displayed. After eight (8) seconds, the display reverts to displaying measured value.

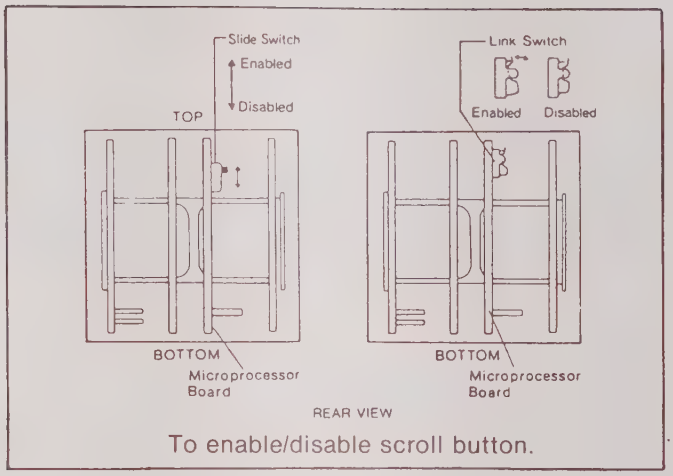


Figure 5.2: Parameter Scroll Disable/Enable Switch

Table 5-2: Control Parameter Steps

Prop Band (%):	0.50, 0.75, 1.00, 1.50, 2, 3, 4, 6, 8, 12, 16, 25, 35, 50, 100.
Integral (seconds):	OFF, 15, 30, 45, 60, 90, 120, 150, 200, 300, 400, 600, 900, 1200, 1800
Derivative (seconds):	OFF, 5, 10, 15, 20, 30, 40, 60, 90, 150, 200, 300, 400, 600
Approach (Relative Prop Band):	0.25, 0.50, 1.00, 1.25, 1.50, 2.00, 2.50, 3.00
Cycle Times (seconds):	0.3, 1, 5, 10, 20, 40, 80
Maximum Power (%):	0 to 100 in 1% steps
Relative Cool Gain (Relative to Heat Output):	0.25, 0.50, 0.75, 1.00, 1.25, 1.50, 2.00, 2.50, 3.00

5.4 Control Stability

The values of Proportional Bandwidth, Integral (Reset) and Derivative (Rate) time constants set in the 810 Controller before it is shipped from the factory have been found by experience to give extremely good control for the majority of systems encountered. However, sometimes it may be necessary to change one or more of these parameters to achieve stable control.

It is possible that a system will not give stable control if one or more of the following conditions exists:

a. The Proportional Bandwidth is too narrow,

b. the Integral time constant (Reset) is too short,

c. the Derivative time constant (Rate) is too long.

The 3-term control algorithm of the 810 Controller implements the PID control parameters to compensate for the system characteristics and provide system stability.

There are many ways of determining optimum control parameter values. The method suggested here is a simple, practical method of stabilization optimization. In cases where stabilization is difficult, it is of great help if a strip chart recording of the start-up response can be obtained.

Control Stability Procedure

1. Set the following control parameter values:

Proportional Band, Pb %	= 12
Integral Time, t_i	= off
Derivative Time, t_d	= off
Heat Maximum Power, HL%	= 100
Approach, AP	= 1.00
Relative Cool Gain, Cr	= 0.50 for water cooled systems
	= 2.0 for air cooled systems

2. Adjust the setpoint of the controller to the desired operating point and allow the system to stabilize. For some systems it could take as long as 30 minutes or more for the system to stabilize.

   The controller measured temperature should rise and stabilize at some point below setpoint. This sag below setpoint is called "droop error", and it will be removed by the addition of Integral Time, ti.

   If the controller measured temperature is oscillating at this point, DO NOT perform step 3.

3. Reduce the value of the Proportional Band until the measured temperature begins to oscillate.

4. Record the period of oscillation (T) for the controller as shown in figure 5-3.

5. Increase the value of the Proportional Band until the measured temperature just stops oscillating.

6. Set the values of Prop Band, Integral, and Derivative as shown below based on the response desired (reference figure 5-3.)

   a. Underdamped Response

      Prop Band—Equal to value determined in step 5.

      Integral Time—Equal to T/2 (seconds)

      Derivative Time—Equal to T/8 (seconds)

b. Normal Response (recommended)

Prop Band—Increase by one setting from the value determined in step 5.

Integral Time—Equal to T (seconds)

Derivative Time—Equal to T/6 (seconds)

c. Overdamped Response

Prop Band—Increase by two settings from the value determined in step 5.

Integral Time—Equal to 1.5T (seconds)

Derivative Time—Equal to T/6 (seconds)

7. For those controllers with a cooling channel the Relative Cool Gain parameter may have to be adjusted. As the controller is required to add cooling, it may cause oscillations in the measured temperature. If this occurs, the Relative Cool Gain parameter should be decreased until the measured temperature stabilizes. If the measured temperature remains above the setpoint, the Relative Cool Gain parameter should be increased. Water cooled systems typically use lower values of relative cool gain, whereas air cooled systems require higher values of relative cool gain. A good rule of thumb for the Relative Cool Gain parameter setting is 0.50 for water cooled systems and 2.0 for air cooled systems.

8. To set the Approach Control parameter, observe the rise of the measured temperature on system start-up as it warms up from cold. If the measured temperature overshoots the setpoint, increase the Approach Control parameter by one (1) setting. If, on the other hand, the measured temperature approaches the setpoint slowly with no overshoot, reduce the Approach Control parameter by one (1) setting. Figure 5.4 shows various start-up responses for a system with the same PID settings but with different Approach Control parameter settings.

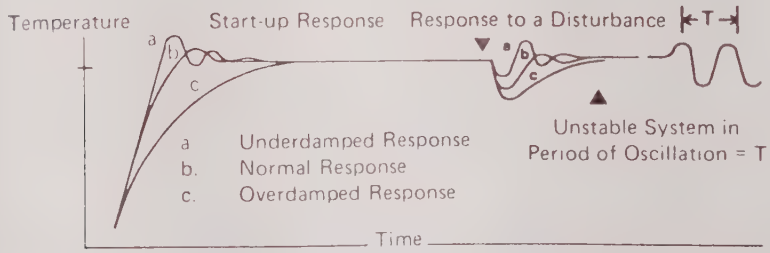


Figure 5-3

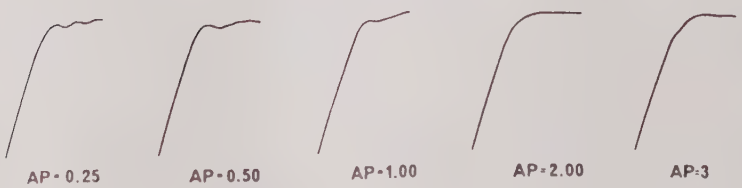


Figure 5-4

5.5 Self-Tuning Option

This section only applies to those instruments fitted with Self-Tuning.

If the Model 810 Controller is ordered with the Self-Tuning option, it will come from the factory with the Self-Tuning Algorithm ENABLED and the PARAMETER SCROLL ENABLE/DISABLE switch in the DISABLE position. With the PARAMETER SCROLL ENABLE/DISABLE switch in the disable position, it will not be possible to view or change any parameter except the setpoint; this includes the Self-Tuning Enable/Disable software switch, tn or tu. On power-up, the Controller will automatically tune the load based on a 1/4 cycle of oscillation at a point halfway between the beginning measured value and the setpoint. The PID parameters will be calculated, and the Controller will then be put into a normal PID control mode with the calculated values of PID.

At a predetermined amount of time, the Controller will start its continuously adaptive control mode. If an error of 4° or greater is detected by the Controller, the Controller will test the response of the system and adjust the proportional band based upon that response.

Self-Tuning may be manually enabled or disabled at any time. Self-Tuning may be manually enabled by depressing the PARAMETER SCROLL pushbutton until the tu or tn mnemonic is displayed. Depressing the RAISE pushbutton will then enable Self-Tuning. Once Self-Tuning is enabled, it cannot be disabled until it is disabled manually as described below. Self-Tuning may be terminated and manually disabled by depressing the PARAMETER SCROLL pushbutton until the tn or tu mnemonic is displayed. Depressing the LOWER pushbutton will then disable Self-Tuning. Once Self-Tuning is disabled, it cannot be enabled until it is enabled manually as described above.

There are three types of Self-Tuning: Start-up Self-Tune, Manual Initiation of Self-Tune (Push-to-Tune), and Continuously Adaptive Self-Tune. Each type of Self-Tune is discussed below.

a. Start-Up Self-Tune

On power-up, the Controller will demand maximum heat power, or it will demand power to the amount given by the Maximum Heat Power parameter, HL. The PID parameters of the Controller are irrelevant, but the values of the HC and AL parameters are relevant. At a point halfway between the starting measured value and the final setpoint, the controller will turn the heat output power off. The self-tuning algorithm will then watch the measured value rise and begin to fall.

The time taken for the measured value to rise to its peak and the amount of temperature rise are related to the values of PID. The Self-Tuning algorithm will calculate the PID values based upon the above stated criteria. The Controller will then be put into a normal PID control mode with these calculated values of PID.

After approximately two integral time constants, the Controller will start its continuously adaptive control mode. See Section 5.6.c for a description of Continuously Adaptive Self-Tuning. Figure 5-5 illustrates a start-up self-tune response curve for a particular load.

b. Manual Initiation of Self-Tune (Push-to-Tune)

When Self-Tuning is initiated manually, the setpoint and current measured value are first checked. If the measured value is less than half of the setpoint, the start-up case described above is assumed. If cooling power is being called for at the time that Self-Tuning is initiated, Self-Tuning will be DISALLOWED. The Controller will operate with the same PID values it had prior to the Manual Initiation of Self-Tune.

If at the time of Manual Initiation of Self-Tune the measured value is above half of the setpoint, the Controller is put into an ON/OFF control mode with a three degree deadband. Heat output power is turned off until the measured value drops three degrees. Heat output power is then applied until the measured value rises two degrees. Heat output power is again turned off, and the new PID parameters are calculated based on the time taken for the measured value to rise to its peak and the amount of temperature rise. The Controller is then put into a normal PID control mode with these new PID values. Figure 5-6 illustrates a Manually Initiated Self-Tune response curve for a particular load.

c. Continuously Adaptive Self-Tuning

When the Controller is operating in a normal PID control mode, the value of the error signal is continuously monitored. Whenever an error of four degrees or greater is observed, but less than the Approach Control parameter, the response of the system is tested.

If the error is corrected in an amount of time less than 1/4 of an integral time constant, the response of the system is judged to be underdamped. If the Controller is calling for heat at the time of the decision, the proportional band is increased by one table setting. If the Controller is calling for cooling at the time of the decision, the relative cool gain is decreased by one table setting.

If the error is not corrected in an amount of time equal to one integral time constant, the response of the system is judged to be overdamped. If the Controller is calling for heat at the time of the decision, the proportional band is decreased by one table setting. If the Controller is calling for cooling at the time of the decision, the relative cool gain is increased by one table setting.

Figure 5-7 illustrates the Continuously Adaptive Self-Tuning Algorithm response curve for a particular load. A perturbation was introduced in order to illustrate this type of self-tuning.

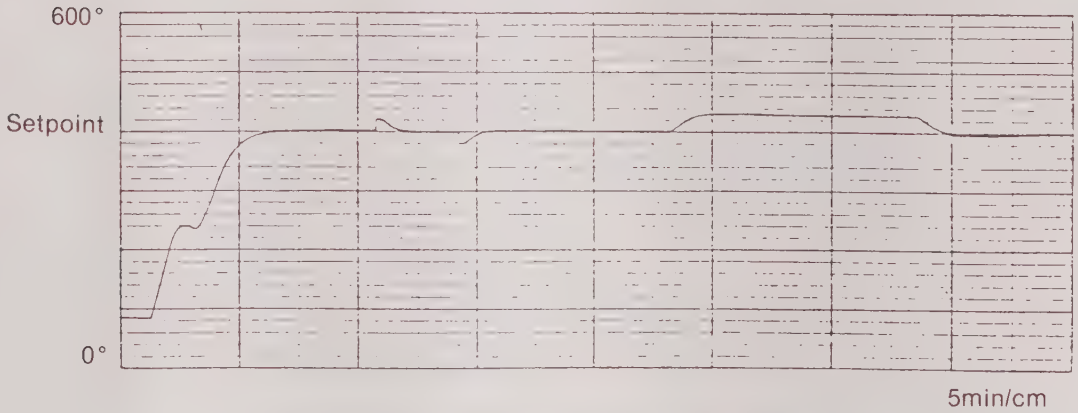


Figure 5-5: Start-Up Self-Tune Response Curve

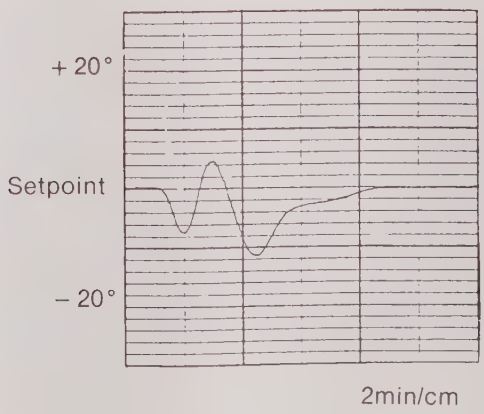


Figure 5-6: Push-to-Tune Response Curve

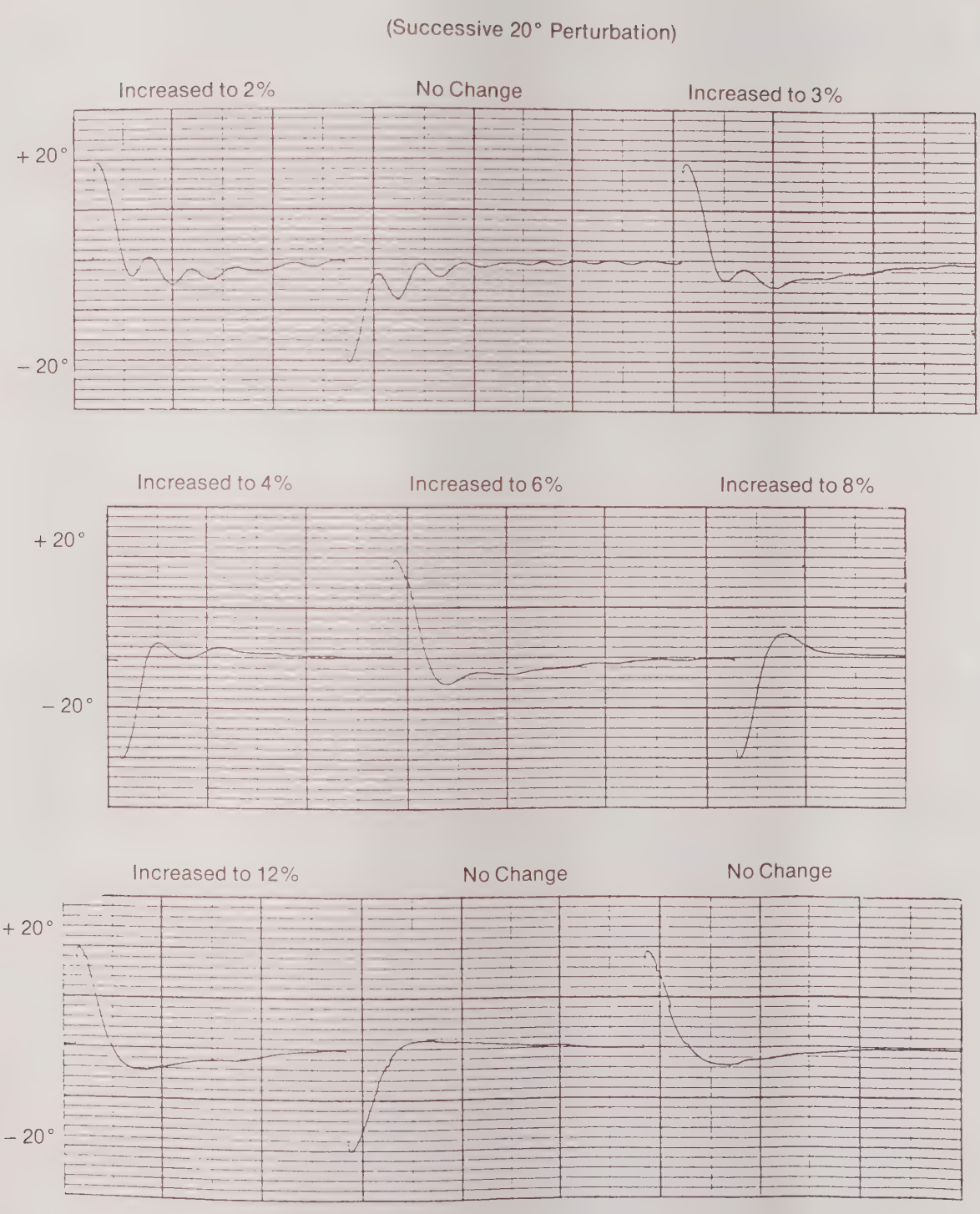


Figure 5-7: Continuously Adaptive Tuning Response Curve

SECTION VI

MAINTENANCE INSTRUCTIONS

6.1 General

This chapter provides information pertaining to the maintenance of the Temperature Controller. Maintenance instructions in this section includes preventive maintenance, cleaning, calibration, disassembly and troubleshooting.

6.2 Preventive Maintenance

Preventive maintenance, when properly performed at prescribed intervals, helps to ensure that the instrument will continue to operate properly. The controller should be inspected periodically so that defects can be corrected before they result in degradation or failure. The preventive maintenance checks and services to be performed are listed and described in Table 6-1. Defects discovered during operation of the unit should be noted and corrected as soon as operation has ceased. Stop the operation immediately if a deficiency is discovered that could result in ultimate damage to the equipment. Reasonable intervals for performing preventive maintenance checks and services should be established based on the operating environment and frequency of operation.

WARNING: Be aware of, and avoid contact with, areas of the equipment where 240 volt, 60 Hz power is normally present. Failure to observe the appropriate safety precautions may result in serious injury due to electrical shock.

6.3 Cleaning

The equipment should be kept free of dust, moisture, grease, and foreign matter. The fascia and exterior of the unit may be cleaned with a lint-free cloth dampened with a mild detergent. The unit should then be wiped with a clean damp cloth.

Table 6-1: Preventive Maintenance Checks and Services

SEQUENCE NUMBER	ITEM TO BE INSPECTED AND PROCEDURE
1	**Connectors and Cable Assemblies** Check wiring and connectors for evidence of bent pins, damaged shells, worn or frayed insulation, and oxidation. Replace damaged parts.
2	**Components** Inspect components for evidence of physical damage or overheating. If discoloration due to overheating is observed, determine the cause of the overheating. Replace the board containing the damaged components.
3	**Screws, Nuts and Bolts** Tighten all loose hardware.
4	**Controls and Indicators** Inspect front panel controls and lamp housings for loose retaining hardware; tighten as necessary. Replace if a switch or lamp housing is physically damaged.

6.4 Dismantling Instructions

The instructions outlined below are referenced to the exploded view of the Controller, figure 3-1.

Turn off all power to the instrument.

Open the front panel access door and with a screwdriver, turn the locking screw located in the bottom right-hand corner of the fascia, counter-clockwise. As the screw is turned, the instrument will start to withdraw from the sleeve. Once the locking screw has been turned to its furthest extent, the instrument can be removed from the sleeve by hand.

Place the instrument on a table. Press in the two black PCB support bracket tabs located at the rear of the instrument and gently ease the PCB support bracket out towards the rear of the instrument. Remove the transformer bracket screw and the triac screw if it is fitted.

Remove the two metal covers by gently pulling them, from the rear of the instrument, to the side of the instrument and disengaging them from their locating lugs on the instrument bezel.

All of the PCBs are now exposed. They can be removed as a unit by easing all of the PCBs out of the instrument bezel. The control pushbuttons will now fall free when the boards are removed. The various boards can now be removed from the motherboard by simply pulling the boards from their motherboard pin connectors. The Isolated D.C. Sub-Boards are soldered to the power supply board, and therefore, they cannot be removed without de-soldering them.

The input board can be removed from the microprocessor board by depressing the input board clip, attached to the microprocessor board, and gently easing the input board away from the microprocessor board.

Reassembling

To reassemble the instrument, fit the control pushbuttons into their respective locations in the instrument bezel. Install the motherboard into the bezel. Install the various P.C. boards into their respective motherboard locations. The bezel is fitted with board guide slots which will be of help when re-installing the PCBs.

Refit the two metal covers to the instrument using their locating lugs on the bezel. The metal cover with three cut holes on the bottom and possibly one cut hole on the top should be installed on the right-hand side of the instrument. The other metal cover with the one cut hole on the top should be installed on the right-hand side of the instrument. Install the transformer bracket screw and the triac screw if it was removed.

Refit the PCB support bracket ensuring that the PCB support bracket tabs are positioned inside the two metal covers and that the PCBs fit into their relevant slots. Press the PCB support bracket towards the front of the instrument until the PCB support bracket tabs click in place.

Insert the instrument into the sleeve. Ease the instrument into the sleeve until firm resistance is met, but DO NOT FORCE the instrument into the sleeve. Open the front panel access door. With a screwdriver, turn the locking screw clockwise until the instrument is pulled completely into the sleeve.

6.5 Calibration

All calibration adjustments are made on the input board. A millivolt source, thermocouple compensating cable and thermocouple reference tables are required for calibration of thermocouple inputs. A source of precision resistance and a platinum resistance thermometer table for the RTD being used is required for calibration of RTD inputs.

The thermocouple calibrating source can be either a cold junction compensating source (Eurotherm Model 239) or an uncompensating source. Procedures for calibration with compensated or uncompensated sources are described below.

All calibration adjustment pots, Zero, Span, and RTD Current Balance, are located on the input board, and they can be accessed through the three holes located on the underneath left-hand side of the Controller. Refer to figure 6-1 during calibration adjustments.

a. Calibration of Thermocouple Inputs with a Compensating Source

1. Connect a calibration source (compensated or uncompensated) to Controller rear terminals 25 (T/C +) and 27 (T/C –).

2. Switch on the supply power to the Controller and to the calibration source and allow 10 minutes for warm-up. Allow a longer time for warm-up if either the Controller or the calibration source was at a radically different temperature other than ambient.

3. In order to achieve the correct thermocouple input characterization, the Controller must be calibrated at the calibration points specified in Table 6-2. Under Table 6-2, locate the Controller thermocouple input type and display range. Adjust the calibration source for the millivolt output specified under the Low Input mV column of Table 6-2.

4. Adjust the zero potentiometer, P2 on the input board, until the measured value indication is identical to the Low Temperature Value listed in Table 6-2.

5. Adjust the calibration source for the millivolt output specified under the High Input mV column of Table 6-2.

6. Adjust the span potentiometer, P3 on the input board, until the measured value indication is identical to the High Temperature Value listed in Table 6-2.

7. Recheck the Controller calibration at the Low mV Input and High mV Input. Adjust the zero and span potentiometers as required.

8. Controller accuracy can be verified at several points throughout the span of the Controller by inputting a millivolt value corresponding to the required temperature. The displayed measured value should be within ± 0.25% of span at each temperature setting.

b. Uncompensating Source

If the calibration source is uncompensating, read the temperature at rear terminals 25 and 27 by means of a thermometer. Obtain the millivolts corresponding to this temperature from the thermocouple reference tables. Reduce the calibration source millivolt output by this amount of millivolts when calibrating the controller as described in subparagraph a.

c. Calibration of Platinum Resistance Thermometer Inputs

1. In order to properly calibrate an RTD input, the Controller must be disassembled. Follow the disassembly instructions under section 6-4 of this manual only to the point of removing the two metal covers and the Channel 2 Output/Alarm Board (if installed). Be sure to reinstall the PCB support bracket before applying power to the Controller to ensure that the PCBs do not accidentally touch each other.

   Note: Be careful to avoid contact with any of the now exposed circuitry as personal injury may result.

2. Referring to figure 6-2, connect a 23K7 resistor in parallel with resistor R1 located on the input board.

3. Jumper rear terminal 25 (R.T. V1) to rear terminal 27 (R.T.I.). Connect a voltmeter between rear terminal 26 (–) (R.T. V2) and rear terminal 25 (+).

   These connections are necessary to order to adjust the RTD Current Balance potentiometer.

4. Switch on the supply power to the Controller and allow 10 minutes for warm-up. Allow a longer time for warm-up if the Controller was at a radically different temperature other than ambient.

5. Adjust the RTD Current Balance potentiometer, P1 on the input board, for a voltmeter reading of 0.00 ± 50mV.

6. Remove the supply power to the Controller. Remove the 23K7 resistor that is in parallel with resistor R1 on the input board. Remove the voltmeter from rear terminals 25 (+) and 26 (−). Remove the jumper from rear terminals 25 and 27. Reassemble the Controller following the reassembly instructions outlined in section 6-4 of this manual.

7. Connect a precision resistance source to Controller rear terminals 25 (R.T. V1) and 26 (R.T. V2). Jumper rear terminal 26 to rear terminal 27 (R.T.I.). Keep the connecting leads as short as possible.

8. Switch on the supply power to the Controller and again allow time for warm-up.

9. In order to achieve the correct RTD input characterization, the Controller must be calibrated at the calibration points specified in Table 6-3. Under Table 6-3, locate the RTD type and display range of the Controller. Adjust the resistance source for the required ohms listed under the Low Ohms Input column of Table 6-3.

10. Adjust the zero potentiometer, P2 on the input board, until the measured value indication is identical to the Low Temperature Value listed in Table 6-3.

11. Adjust the resistance source for the required ohms listed under the High Ohms Input column of Table 6-3.

12. Adjust the span potentiometer, P3 on the input board, until the measured value indication is identical to the High Temperature Value listed in Table 6-3.

13. Recheck the Controller calibration at the Low Ohms Input and the High Ohms Input. Adjust the zero and span potentiometers as required.

14. Controller accuracy may be verified at several points throughout the span of the Controller by inputting a resistance value corresponding to the required temperature. The displayed measured value should be within ±0.25% of span at each temperature setting.

d. Calibration of Linear Inputs (Voltage and Current)

1. Connect a calibration source (either a voltage or current source) to Controller rear terminals 25 (D.C.+) and 26 (D.C.−).

2. Switch on the supply power to the Controller and to the calibration source and allow 10 minutes for warm-up. Allow a longer time for warm-up if either the Controller or the calibration source was at a radically different temperature other than ambient.

3. Adjust the calibration source for the "zero" input of the Controller.

4. Adjust the zero potentiometer, P2 on the input board, until the measured value indication is identical to the "zero" display indication of the Controller.

5. Adjust the calibration source for the "span" input of the Controller.

6. Adjust the span potentiometer, P3 on the input board, until the measured value indication is identical to the "span" display indication of the Controller.

7. Recheck the Controller calibration at the zero and span inputs. Adjust the zero and span potentiometers as required.

8. Controller accuracy may be verified at several points throughout the span of the Controller by inputting a voltage or current signal corresponding to a displayed measured value. The displayed measured value indication should be within ± 0.25% of Controller span at each input.

6.6 Troubleshooting Guide

If, upon completion of installation or during normal operation, the instrument fails to function properly, check all installation wiring for loose or faulty wiring connections. Particularly check that the AC power connections are wired to the correct terminals. If these items are correct, refer to Table 6-4, "Troubleshooting Guide", to assist in isolating common malfunctions. Potential problems which could be at fault and recommendations for corrective action are listed in Table 6-4.

Note: 1. Before troubleshooting the Controller, ensure that the heat maximum power parameter, HL, is set to 100%.

2. If a fault is indicated in the thermocouple or thermocouple interconnections, confirmation of this can be made as follows:

   Disconnect the compensating cable from the Controller thermocouple terminals and connect a millivolt source to these terminals. Check that the controller measured value indication moves up and down the scale as the millivolt signal corresponding to temperatures above and below the setpoint are injected. If the measured value indication fails to respond in this way, an internal fault exists in the Controller.

Table 6.4: Troubleshooting Guide

Condition	Fault	Action
With Supply Power on: Controller display does not illuminate.	a. Break in supply power connection (fuse or breaker) or b. incorrect rear terminal supply power connections or c. power supply/channel 1 output board not set up for correct supply power voltage—wrong links fitted or d. Controller transformer failure or e. Controller not seated properly in sleeve	a. Check supply power connections, fuses and breakers. Check for cause of fuse failure before replacing fuse b. Check rear terminal connections c. Fit 120V links or 240V links as required d. Replace controller transformer e. Check controller for proper installation
Error bargraph indication is upscale and display is blank.	Break in thermocouple or compensating cable	Replace thermocouple or compensating cable and check all connections
Error bargraph indication is downscale, output 1 LED is ON, but heating power is off.	Break in load connection (fuse or breaker)	Check load connections, fuses and breakers. Check for cause of fuse failure before replacing fuse
Error bargraph indication is downscale, output 1 LED is OFF, and heating power is off (for an extended period of time).	a. Channel 1 output failure b. possible tuning problem	a. Replace channel 1 output b. See section 5.4 of this manual

Table 6.4: Troubleshooting Guide

Condition	Fault	Action
Error bargraph indication is upscale, output 1 LED is OFF, but full heating power is on.	a. Short circuit in load wiring or b. external SCRs either latched on or broken down	a. Check/repair load wiring b. Check/Repair/Replace external SCR device
Error bargraph indication is downscale, output 1 LED is ON, Controller display is blank, and heating power is on.	a. Incorrect thermocouple or compensating cable connections (polarity) b. downscale break option	a. Reconnect thermocouple or compensating cable with correct polarity b. Check thermocouple or compensating cable for an open circuit
With dual output controller—error bargraph indication is upscale, output 2 LED is ON, but cooling power is off.	a. Break in cooling load connection, fuses or breakers or b. solenoid valve stuck or c. faulty pilot relay	a. Check cooling load connections, fuses and breakers. Check cause of fuse failure before replacing fuse or b. Check solenoid valve c. Check pilot relay
With dual output controller—error bargraph indication is upscale, output 2 LED is OFF, and cooling power is off (for an extended period of time).	a. Channel 2 output stage failure or b. possible tuning problem	a. Replace channel 2 output b. See section 5.4 of this manual
With system at temperature, the temperature indication swings regularly above and below setpoint and error bargraph swings with temperature.	a. Excessively narrow proportional band or b. incorrect time constants	a. Increase proportional band b. Modify time constants c. See section 5.4 of the manual
With system at temperature, the temperature indication and error bargraph indication are steady, but an error exists between actual temperature and set temperature as indicated on the display.	a. Proportional only control or b. improper tuning	a. Check proportional band and time constants (Pb, ti, td) b. See section 5.4 of this manual
With system at temperature, temperature indication hunts in a random manner.	a. Poor thermocouple connection or b. thermocouple junction deteriorating or c. improper tuning	a. Check/repair thermocouple connection b. Replace thermocouple c. See section 5.4 of this manual

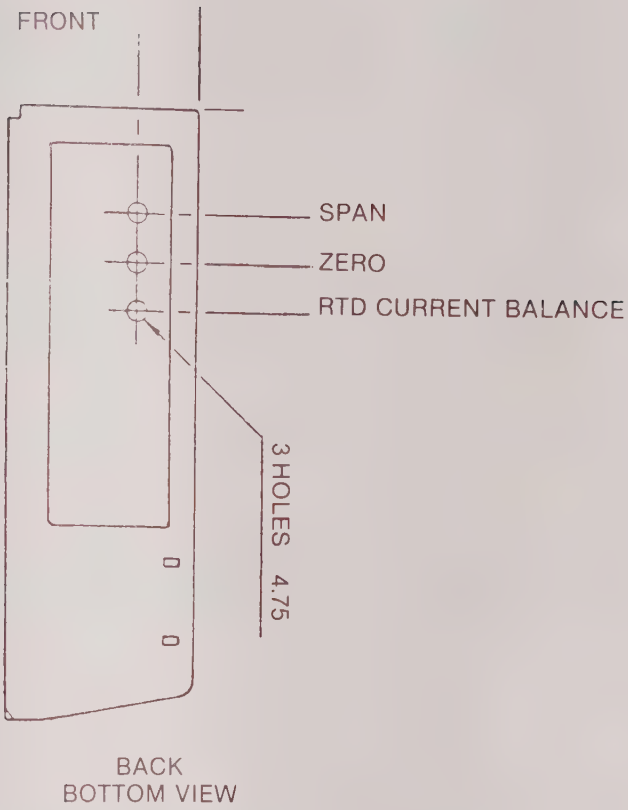


Figure 6-1: 810 Calibration Adjustments

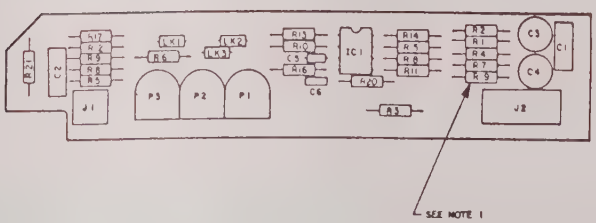


Figure 6-2: Input Board Component Layout

Table 6.2: Thermocouple Calibration Data

THERMOCOUPLE TYPE	DISPLAY RANGE	TABLE RANGE	Calibration Points			
			LOW INPUT mV (mV)	LOW TEMPERATURE VALUE	HIGH INPUT mV (mV)	HIGH TEMPERATURE VALUE
J Iron versus Constantan NBS (National Bureau of Standards)	± 250°C ± 125°C 0-50.0°C 0-100.0°C 0-200°C 0-300°C 0-400°C 0-600°C 0-800°C 0-1000°C	± 250 ± 125 0-125 0-125 0-250 0-500 0-500 0-1000 0-1000 0-1000	– 4.632 – 4.632 + 0.101 + 0.101 0.0 + 0.303 + 0.303 + 1.277 + 1.277 + 1.277	– 100°C – 100°C + 2°C + 2°C 0°C + 6°C + 6°C + 25°C + 25°C + 25°C	+ 13.553 + 6.359 + 6.523 + 6.523 + 12.720 + 25.994 + 25.994 + 50.621 + 50.621 + 50.621	+ 250°C + 120°C + 123°C + 123°C + 235°C + 475°C + 475°C + 880°C + 880°C + 880°C
J Iron versus Constantan NBS (National Bureau of Standards)	± 500°F ± 250°F ± 125°F 0-50.0°F 0-100.0°F 0-200°F 0-300°F 0-400°F 0-600°F 0-800°F 0-1000°F 0-1200°F 0-1600°F 0-2000°F	± 500 ± 250 ± 125 0-125 0-125 0-250 0-500 0-500 0-1000 0-1000 0-1000 0-2000 0-2000 0-2000	– 0.748 – 6.716 – 3.930 – 0.885 – 0.885 + 0.507 + 0.648 + 0.648 – 0.611 – 0.611 – 0.611 + 3.115 + 3.115 + 3.115	+ 5°F – 250°F – 118°F 0°F 0°F + 50°F + 55°F + 55°F + 10°F + 10°F + 10°F + 140°F + 140°F + 140°F	+ 11.023 + 6.420 + 2.673 + 2.526 + 2.526 + 5.509 + 9.790 + 9.790 + 24.853 + 24.853 + 24.853 + 39.407 + 39.407 + 39.407	+ 400°F + 250°F + 125°F + 120°F + 120°F + 220°F + 360°F + 360°F + 850°F + 850°F + 850°F + 1300°F + 1300°F + 1300°F
B Platinum-30% Rhodium versus Platinum- Rhodium (Hoskins Manufacturing Company)	0-600°C 0-800°C 0-1000°C 0-1200°C 0-1600°C 0-2000°C	0-1000 0-1000 0-1000 0-2000 0-2000 0-2000	+ 0.778 + 0.778 + 0.778 + 3.957 + 3.957 + 3.957	+ 398°C + 398°C + 398°C + 900°C + 900°C + 900°C	+ 4.386 + 4.386 + 4.386 + 10.616 + 10.616 + 10.616	+ 950°C + 950°C + 950°C + 1545°C + 1545°C + 1545°C

Table 6.2

THERMOCOUPLE TYPE	DISPLAY RANGE	TABLE RANGE	Calibration Points			
			LOW INPUT mV (mV)	LOW TEMPERATURE VALUE	HIGH INPUT mV (mV)	HIGH TEMPERATURE VALUE
B Platinum-30% Rhodium versus Platinum-6% Rhodium (Hoskins Manufacturing Company)	0-1200°F 0-1600°F 0-2000°F 0-2400°F 0-3000°F 0-4000°F	0-2000 0-2000 0-2000 0-4000 0-4000 0-4000	+ 0.898 + 0.898 + 0.898 + 7.473 + 7.473 + 7.473	+ 800°F + 800°F + 800°F + 2310°F + 2310°F + 2310°F	+ 4.873 + 4.873 + 4.873 + 9.889 + 9.889 + 9.889	+ 1840°F + 1840°F + 1840°F + 2700°F + 2700°F + 2700°F
S Platinum-10% Rhodium versus Platinum NBS (National Bureau of Standards)	0-1200°F 0-1600°F 0-2000°F 0-2400°F 0-3000°F 0-4000°F	0-2000 0-2000 0-2000 0-4000 0-4000 0-4000	+ 2.985 + 2.985 + 2.985 + 4.333 + 4.333 + 4.333	+ 700°F + 700°F + 700°F + 950°F + 950°F + 950°F	+ 8.436 + 8.436 + 8.436 + 15.027 + 15.027 + 15.027	+ 1650°F + 1650°F + 1650°F + 2650°F + 2650°F + 2650°F
S Platinum-10% Rhodium versus Platinum NBS (National Bureau of Standards)	0-600°C 0-800°C 0-1000°C 0-1200°C 0-1600°C 0-2000°C	0-1000 0-1000 0-1000 0-2000 0-2000 0-2000	+ 2.277 + 2.277 + 2.277 + 3.260 + 3.260 + 3.260	+ 295°C + 295°C + 295°C + 400°C + 400°C + 400°C	+ 9.585 + 9.585 + 9.585 + 12.308 + 12.308 + 12.308	+ 1000°C + 1000°C + 1000°C + 1230°C + 1230°C + 1230°C
E Nickel-Chromium versus Copper-Nickel NBS (National Bureau of Standards)	± 250°C 0-600°C 0-800°C 0-1000°C	± 250 0-1000 0-1000 0-1000	− 6.231 + 6.656 + 6.656 + 6.656	− 123°C + 105°C + 105°C + 105°C	+ 13.419 + 75.608 + 75.608 + 75.608	+ 200°C + 990°C + 990°C + 990°C
E Nickel-Chromium versus Copper Nickel NBS (National Bureau of Standards)	± 500°F 0-1200°F 0-1600°F 0-2000°F	± 500 0-2000 0-2000 0-2000	− 3.650 + 13.955 + 13.955 + 13.955	− 85°F + 405°F + 405°F + 405°F	+ 13.748 + 57.873 + 57.873 + 57.873	+ 400°F + 1400°F + 1400°F + 1400°F

Table 6.2

THERMOCOUPLE TYPE	DISPLAY RANGE	TABLE RANGE	Calibration Points			
			LOW INPUT mV (mV)	LOW TEMPERATURE VALUE	HIGH INPUT mV (mV)	HIGH TEMPERATURE VALUE
PL2 Platinel II (Engelhard Industries)	± 250°F 0-600°F 0-800°F 0-1000°F 0-1200°F 0-1600°F 0-2000°F	± 250 0-1000 0-1000 0-1000 0-2000 0-2000 0-2000	– 1.641 – 1.983 – 1.983 – 1.983 + 11.471 + 11.471 + 11.471	– 75°F – 100°F – 100°F – 100°F + 580°F + 580°F + 580°F	+ 3.863 + 20.606 + 20.606 + 20.606 + 41.155 + 41.155 + 41.155	+ 240°F + 950°F + 950°F + 950°F + 1815°F + 1815°F + 1815°F
G2 W/W 26% Re Tungsten versus Tungsten 26% Rhenium (Hoskins Manufacturing Company)	0-1200°C 0-1600°C 0-2000°C	0-2000 0-2000 0-2000	+ 8.076 + 8.076 + 8.076	+ 685°C + 685°C + 685°C	+ 33.367 + 33.367 + 33.367	+ 1960°C + 1960°C + 1960°C
G2 W/W 26% Re Tungsten versus Tungsten 26% Rhenium (Hoskins Manufacturing Company)	0-1200°F 0-1600°F 0-2000°F 0-2400°F 0-3000°F 0-4000°F	0-2000 0-2000 0-2000 0-4000 0-4000 0-4000	+ 4.562 + 4.562 + 4.562 + 17.174 + 17.174 + 17.174	+ 900°F + 900°F + 900°F + 2070°F + 2070°F + 2070°F	+ 15.182 + 15.182 + 15.182 + 36.312 + 36.312 + 36.312	+ 1900°F + 1900°F + 1900°F + 3900°F + 3900°F + 3900°F
C Tungsten 5% Rhenium versus Tungsten 26% Rhenium (Hoskins Manufacturing Company)	0-1200°C 0-1600°C 0-2000°C	0-2000 0-2000 0-2000	+ 6.731 + 6.731 + 6.731	+ 400°C + 400°C + 400°C	+ 29.617 + 29.617 + 29.617	+ 1695°C + 1695°C + 1695°C
C Tungsten 5% Rhenium versus Tungsten Rhenium 26% (Hoskins Manufacturing Comp	0-2400°F 0-3000°F 0-4000°F	0-4000 0-4000 0-4000	+ 10.475 + 10.475 + 10.475	+ 1100°F + 1100°F + 1100°F	+ 21.991 + 21.991 + 21.991	+ 2210°F + 2210°F + 2210°F

Table 6.2

THERMOCOUPLE TYPE	DISPLAY RANGE	TABLE RANGE	Calibration Points			
			LOW INPUT mV (mV)	LOW TEMPERATURE VALUE	HIGH INPUT mV (mV)	HIGH TEMPERATURE VALUE
D Tungsten 3% Rhenium versus Tungsten 25% Rhenium (Hoskins Manufacturing Company)	0-600°C 0-800°C 0-1000°C 0-1200°C 0-1600°C 0-2000°C	0-1000 0-1000 0-1000 0-2000 0-2000 0-2000	+ 4.771 + 4.771 + 4.771 + 6.996 + 6.996 + 6.996	+ 327°C + 327°C + 327°C + 445°C + 445°C + 445°C	+ 14.171 + 14.171 + 14.171 + 31.413 + 31.413 + 31.413	+ 800°C + 800°C + 800°C + 1720°C + 1720°C + 1720°C
R Platinum-13% Rhodium versus Platinum NBS (National Bureau of Standards)	0-600°C 0-800°C 0-1000°C 0-1200°C 0-1600°C 0-2000°C	0-1000 0-1000 0-1000 0-2000 0-2000 0-2000	+ 0.610 + 0.610 + 0.610 + 5.526 + 5.526 + 5.326	+ 95°C + 95°C + 95°C + 595°C + 595°C + 595°C	+ 8.696 + 8.696 + 8.696 + 14.624 + 14.624 + 14.624	+ 860°C + 860°C + 860°C + 1300°C + 1300°C + 1300°C
D Tungsten 3% Rhenium versus Tungsten 25% Rhenium (Hoskins Manufacturing Company)	0-1200°F 0-1600°F 0-2000°F 0-2400°F 0-3000°F 0-4000°F	0-2000 0-2000 0-2000 0-4000 0-4000 0-4000	+ 3.078 + 3.078 + 3.078 + 7.725 + 7.725 + 7.725	+ 445°F + 445°F + 445°F + 900°F + 900°F + 900°F	+ 13.579 + 13.579 + 13.579 + 22.334 + 22.334 + 22.334	+ 1420°F + 1420°F + 1420°F + 2210°F + 2210°F + 2210°F
T Copper versus Copper Nickel NBS (National Bureau of Standards)	± 500°F ± 250°F ± 125°F 0-50.0°F 0-100.0°F 0-200°F 0-300°F 0-400°F 0-600°F 0-800°F 0-1000°F	± 500 ± 250 ± 125 0-125 0-125 0-250 0-500 0-500 0-1000 0-1000 0-1000	− 2.973 − 3.039 − 3.006 − 0.571 − 0.571 − 0.674 − 0.571 − 0.571 + 0.065 + 0.065 + 0.065	− 123°F − 127°F − 125°F + 5°F + 5°F 0°F + 5°F + 5°F + 35°F + 35°F + 35°F	+ 12.572 + 4.749 + 1.105 + 1.403 + 1.403 + 3.839 + 12.572 + 12.572 + 15.118 + 15.118 + 15.118	+ 500°F + 230°F + 82°F + 95°F + 95°F + 195°F + 500°F + 500°F + 580°F + 580°F + 580°F

Table 6.2

THERMOCOUPLE TYPE	DISPLAY RANGE	TABLE RANGE	Calibration Points			
			LOW INPUT mV (mV)	LOW TEMPERATURE VALUE	HIGH INPUT mV (mV)	HIGH TEMPERATURE VALUE
K	± 500°F	± 500	– 3.637	– 153°F	+ 10.151	+ 482°F
Nickel-Chromium	± 250°F	± 250	– 2.699	– 100°F	+ 2.666	+ 150°F
versus	± 125°F	± 125	– 2.920	– 112°F	+ 2.091	+ 125°F
Nickel-Aluminum	0-50.0°F	0-125	0.0	0°F	+ 2.045	+ 123°F
NBS (National	0-100.0°F	0-125	0.0	0°F	+ 2.045	+ 123°F
Bureau of	0-200°F	0-250	+ 0.242	+ 43°F	+ 4.919	+ 248°F
Standards)	0-300°F	0-500	– 0.262	+ 20°F	+ 9.027	+ 432°F
	0-400°F	0-500	– 0.262	+ 20°F	+ 9.027	+ 432°F
	0-600°F	0-1000	+ 1.657	+ 106°F	+ 17.994	+ 820°F
	0-800°F	0-1000	+ 1.657	+ 106°F	+ 17.994	+ 820°F
	0-1000°F	0-1000	+ 1.657	+ 106°F	+ 17.994	+ 820°F
	0-1200°F	0-2000	+ 1.181	+ 85°F	+ 37.724	+ 1670°F
	0-1600°F	0-2000	+ 1.181	+ 85°F	+ 37.724	+ 1670°F
	0-2000°F	0-2000	+ 1.181	+ 85°F	+ 37.724	+ 1670°F
	0-2400°F	0-4000	+ 1.203	+ 86°F	+ 54.807	+ 2496°F
	0-2500°F	0-4000	+ 1.203	+ 86°F	+ 54.807	+ 2496°F
	0-3000°F	0-4000	+ 1.203	+ 86°F	+ 54.807	+ 2496°F
	0-4000°F	0-4000	+ 1.203	+ 86°F	+ 54.807	+ 2496°F

Table 6.2

THERMOCOUPLE TYPE	DISPLAY RANGE	TABLE RANGE	Calibration Points			
			LOW INPUT mV (mV)	LOW TEMPERATURE VALUE	HIGH INPUT mV (mV)	HIGH TEMPERATURE VALUE
R Platinum-13% Rhodium versus Platinum NBS (National Bureau of Standards)	0-1200°F 0-1600°F 0-2000°F 0-2400°F 0-3000°F 0-4000°F	0-2000 0-2000 0-2000 0-4000 0-4000 0-4000	+ 2.818 + 2.818 + 2.818 + 3.110 + 3.110 + 3.110	+ 648°F + 648°F + 648°F + 700°F + 700°F + 700°F	+ 8.141 + 8.141 + 8.141 + 17.975 + 17.975 + 17.975	+ 1500°F + 1500°F + 1500°F + 2800°F + 2800°F + 2800°F
PL2 Platinel II (Engelhard Industries)	± 250°C 0-300°C 0-400°C 0-600°C 0-800°C 0-1000°C 0-1200°C 0-1600°C 0-2000°C	± 125 0-500 0-500 0-1000 0-1000 0-1000 0-2000 0-2000 0-2000	− 2.594 + 0.925 + 0.925 + 8.127 + 8.127 + 8.127 0.0 0.0 0.0	− 100°C + 30°C + 30°C + 225°C + 225°C + 225°C 0°C 0°C 0°C	+ 3.843 + 18.352 + 18.352 + 40.743 + 40.743 + 40.743 + 74.204 + 74.204 + 74.204	+ 115°C + 460°C + 460°C + 980°C + 980°C + 980°C + 2000°C + 2000°C + 2000°C

Table 6.2

THERMOCOUPLE TYPE	DISPLAY RANGE	TABLE RANGE	Calibration Points			
			LOW INPUT mV (mV)	LOW TEMPERATURE VALUE	HIGH INPUT mV (mV)	HIGH TEMPERATURE VALUE
T Copper versus Copper Nickel NBS (National Bureau of Standards)	± 250°C ± 125°C 0-50.0°C 0-100.0°C 0-200°C 0-300°C 0-400°C	± 250 ± 125 0-125 0-125 0-250 0-500 0-500	– 5.069 – 1.819 – 0.193 – 0.193 + 0.117 + 0.992 + 0.992	– 170°C – 50°C – 5°C – 5°C + 3°C + 25°C + 25°C	+ 9.021 + 5.131 + 4.987 + 4.987 + 9.820 + 15.443 + 15.443	+ 195°C + 118°C + 115°C + 115°C + 210°C + 310°C + 310°C
K Nickel- Chromium versus Nickel Aluminum NBS (National Bureau of Standards)	± 250°C ± 125°C 0-50.0°C 0-100.0°C 0-200°C 0-300°C 0-400°C 0-600°C 0-800°C 0-1000°C 0-1200°C 0-1600°C 0-2000°C	± 250 ± 125 0-125 0-125 0-250 0-500 0-500 0-1000 0-1000 0-1000 0-2000 0-2000 0-2000	– 1.745 – 1.709 0.0 0.0 + 1.693 0.0 0.0 + 2.022 + 2.022 + 2.022 + 1.203 + 1.203 + 1.203	– 46°C – 45°C 0°C 0°C + 42°C 0°C 0°C + 50°C + 50°C + 50°C + 30°C + 30°C + 30°C	+ 9.745 + 5.124 + 3.473 + 3.473 + 10.070 + 16.691 + 16.691 + 37.325 + 37.325 + 37.325 + 54.807 + 54.807 + 54.807	+ 240°C + 125°C + 85°C + 85°C + 248°C + 407°C + 407°C + 900°C + 900°C + 900°C + 1370°C + 1370°C + 1370°C

Table 6. RTD Calibration Data

RTD TYPE	DISPLAY RANGE	TABLE RANGE	Calibration Points			
			LOW INPUT Ohms (OHMS)	LOW TEMPERATURE VALUE	HIGH INPUT Ohms (OHMS)	HIGH TEMPERATURE VALUE
100 OHM RTD	± 250°C	± 250	33.43	– 165°C	127.07	+ 70°C
	± 125°C	± 125	72.35	– 70°C	142.29	+ 110°C
	0-50.0°C	0-125	104.68	+ 12°C	138.50	+ 100°C
	0-100.0°C	0-125	104.68	+ 12°C	138.50	+ 100°C
	0-200°C	0-250	114.38	+ 37°C	161.04	+ 160°C
	0-300°C	0-500	103.90	+ 10°C	190.45	+ 240°C
	0-400°C	0-500	103.90	+ 10°C	190.45	+ 240°C
	0-600°C	0-1000	117.47	+ 45°C	304.02	+ 570°C
	0-800°C	0-1000	117.47	+ 45°C	304.02	+ 570°C
	0-1000°C	0-1000	117.47	+ 45°C	304.02	+ 570°C
100 OHM RTD	0-50.0°F	0-125	99.61	+ 8°F	118.97	+ 120°F
	0-100.0°F	0-125	99.61	+ 8°F	118.97	+ 120°F
	0-200°F	0-250	95.22	+ 10°F	132.80	+ 185°F
	0-300°F	0-500	109.35	+ 75°F	181.56	+ 420°F
	0-400°F	0-500	109.35	+ 75°F	181.56	+ 420°F
	0-600°F	0-1000	97.39	+ 20°F	167.24	+ 350°F
	0-800°F	0-1000	97.39	+ 20°F	167.24	+ 350°F
	0-1000°F	0-1000	97.39	+ 20°F	167.24	+ 350°F
	0-1200°F	0-2000	103.90	+ 50°F	293.52	+ 1000°F
	0-1600°F	0-2000	103.90	+ 50°F	293.52	+ 1000°F
	0-2000°F	0-2000	103.90	+ 50°F	293.52	+ 1000°F

CM FURNACES, Inc.

EFFECTIVE JULY 1, 1987

RAPID TEMP LAB FURNACE PRICE LIST

SELECT DESIRED FURNACE FROM TABLE A, AND POWER SUPPLY FROM TABLE B,
OPTIONS FROM TABLE C, REPLACEMENT & SPARE PARTS FROM TABLE D
REFER TO TABLE E WHEN ORDERING

TABLE A FURNACES

Fan cooling is supplied as standard on all units with the exception of the VTF and bottom loading version.
The KBL system is supplied as a complete package including instrumentation.

MODEL	M	A	B	C	D	HTF	VTF	KBL
1600 Series	$3,795	4,460	4,925	5,595	5,975	4,650	5,395	—
1700S Series	**4,225**	5,225	5,795	**6,550**	6,895	**5,175**	6,585	8,995
1700 Series	4,875	5,895	5,975	7,475	8,395	5,650	6,675	—

TABLE B POWER SUPPLY SYSTEMS

All systems are priced as a **complete package** including a solid state SCR power controller, stepdown transformer, circuit breaker, ammeter, switches, Type B thermocouples, cabinetry, interconnecting wiring—ready for immediate installation. All systems feature **independent overtemperature instrumentation** operating with a separate Type B thermocouple as standard.

SET POINT TEMPERATURE CONTROL SYSTEMS	M, A & HTF	B, C, D & VTF
EUROTHERM 810 MICROPROCESSOR CONTROLLER	**$ 3,775**	**$ 4,250**
EUROTHERM 818S or 820 MICROPROCESSOR CONTROLLER	4,495	4,995
BARBER COLMAN 560 MICROPROCESSOR CONTROLLER	4,995	5,665
L & N ELECTROMAX VPLUS MICROPROCESSOR CONTROLLER	5,485	6,125

PROGRAMMABLE TEMPERATURE CONTROL SYSTEMS

EUROTHERM 812 MICROPROCESSOR PROGRAMMER 4 SEG	**$ 4,395**	**$ 4,895**
EUROTHERM 818P or 821 MICROPROCESSOR PROGRAMMER 16 SEG	5,475	6,025
EUROTHERM 822 MICROPROCESSOR PROGRAMMER 30 SEG	6,275	6,825
BARBER COLMAN 570 MICROPROCESSOR PROGRAMMER 96 SEG	6,925	7,275
HONEYWELL DCP 7700 MICROPROCESSOR PROGRAMMER 99 SEG	12,950	13,425
HONEYWELL 511 MICROPROCESSOR PROGRAMMER 220 SEG	8,075	8,825
L & N ELECTROMAX V PLUS MICROPROCESSOR PROGRAMMER 10 SEG	5,895	6,495
RESEARCH INC. MICRISTAR MICROPROCESSOR PROGRAMMER 50 SEG	7,165	7,725
RESEARCH INC. MICRICON MICROPROCESSOR PROGRAMMER 40 SEG	10,865	11,495

PRICES SUBJECT TO CHANGE WITHOUT NOTICE

TABLE C OPTIONS

OPTIONS FURNACE	AVAILABILITY	ADDER
SPLIT VERTICAL TUBE FURNACE	VTF	ON REQUEST
BOTTOM LOADING MANUAL	M & A	$ 995.00
BOTTOM LOADING PRECISION POWER LIFT	B, C & D	2,850.00
GAS PORTS (ENRICHING ATMOSPHERE)	M, A, B, C & D	N/C
SIGHT PORT	M, A, B, C & D	N/C
INERT ATMOSPHERE SEALED SYSTEM (FRONT LOADING)	M, A, B, C & D	3,825.00
INERT ATMOSPHERE END SEALS (2 SUPPLIED)	HTF & VTF	295.00
CAST FIBER PLUG	HTF & VTF	175.00
UNIVERSAL SUPPORT STAND, SWIVEL BRACKETS & MOUNTING PLATE	VTF	750.00
MODIFICATIONS FOR MATERIAL TESTING EQUIP.	ALL MODELS	ON REQUEST

OPTIONS POWER SUPPLY

RECORDING INSTRUMENTATION	ALL MODELS	ON REQUEST
EUROTHERM MODEL 140 DIGITAL TEMP INDICATOR	ALL MODELS	525.00
*MULTI-TAP STEPDOWN TRANSFORMER 5 KVA	M, A & HTF	510.00
*MULTI-TAP STEPDOWN TRANSFORMER 10 KVA	B, C, D & VTF	785.00

*Required only if power supply system is not ordered.

TABLE D REPLACEMENT & SPARE PARTS

	MODEL	PART NO.	PRICE	
HEATING ELEMENTS	M, A, & HTF	B-680X	$127.00 ea	
HEATING ELEMENTS WITH HOLDER	M, A, & HTF	B-680	147.00 ea	
HEATING ELEMENTS	B & C	B-737X	139.00 ea	
HEATING ELEMENTS WITH HOLDER	B & C	B-737	159.00 ea	
HEATING ELEMENTS	D & VTF	B-782X	154.00 ea	
HEATING ELEMENTS WITH HOLDER	D & VTF	B-782	174.00 ea	
HEATING ELEMENTS WITH HOLDER	KBL	10200-00	131.75 ea	
THERMOCOUPLE TYPE B	M, A, B, C, D, VTF	H-499-4	174.00 ea*	
THERMOCOUPLE TYPE B	HTF	H-499-6	232.00 ea*	
THERMOCOUPLE TYPE B	GAS SEALED	H-489	259.00 ea*	
CONNECTOR STRAPS	SPECIFY	SPECIFY	6.50 ea	
CLAMPS	ALL		5.50 ea	
ZIRCONIA FLOOR PLATE			18.50 ea	
ALUMINA FLOOR PLATE			15.00 ea	
MULLITE TUBE 2½ × 24——2½ × 30			98.50	128.50
ALUMINA TUBE 2½ × 24——2½ × 30			210.00	228.50
REPLACEMENT FUSES FOR ALL POWER CONTROLLERS			ON REQUEST	

*Price may vary depending on precious metal market value

NOTE: PLEASE INDICATE FURNACE SERIAL NUMBER WHEN ORDERING SPARE PARTS

TABLE E ORDERING INFORMATION

ALL PRICES ARE FACTORY FLOOR, BLOOMFIELD, N.J. PLEASE ADD $150.00 FOR PACKAGING AND CRATING FOR DOMESTIC SHIPMENT. ADD $75.00 IF FURNACE ONLY IS ORDERED.

To avoid delays please specify primary voltage at your facility 208 or 240V single phase.

MP MASTER
MA32895